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PUBLIC WORKS
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Maintenance Service for Fifty Municipalities

Meter testing and repair shop and fifty-eight trucks employed by Hackensack Water Company in maintaining nearly sixty thousand services in fifty municipalities, and installing about four thousand new ones a year.

Maintaining more than 56,000 services in fifty municipalities and adding to them at the rate of 50 a day—every service metered; and maintaining the mains and fire hydrants and adding to them at the rate of 25 to 30 miles of mains and 250 hydrants a year; all from one central office; this is the job that the Hackensack Water Company is doing at its office in Weehawken.

The entire territory that the company serves, located in the northeastern part of New Jersey, is divided into six commercial districts—Weehawken, Englewood, Westwood, Rutherford, Hackensack, and Ridgefield Park, each with its local supervisor and office, from which the routine business is conducted. (In addition, five municipalities over the state line in New York are served by a subsidiary company, the Spring Valley Water Works and Supply Company, the meters of which are repaired and tested at the Weehawken plant.)

Aside from the general business of the local offices, the entire system is looked after from the central office. A construction department lays and repairs street mains, hydrants and services over 2 inches in size. A service department makes and renews services to the curb. An inspection and service repair department keeps the services in shape, looking for and repairing leaks, removing stoppages and generally keeping the services in effective condition. The paving department replaces all pavement (except sheet asphalt wearing surface) that has been removed by the company in making street openings. The meter department tests all meters, makes all meter repairs, and generally looks after the sixty thousand meters from the time they are received from the manufacturers until they are too worn for further sevice. All of these departments use automobiles—58 in all—and an automobile repair department keeps them in first class condition.

METER DEPARTMENT

To the engineer and superintendent the meter department is perhaps the most interesting. This occupies practically an entire floor of a building adjacent to the general offices. Here is a shop containing four meter testing machines for ⅝-inch meters, one for 2-inch, and one for larger meters up to 10-inch. There are also two endurance test sets, and one for making pressure tests. The latter is used on meters of types other than the company's standard, which are subjected to a pressure of 350 pounds. Around three sides of the room are benches where the meters are taken apart, repaired and assembled. These face thirteen windows, while a large skylight in the roof gives abundant light to the centre of the room, where, in addition to the meter testing machines, are a large lathe for repairing 6-inch and larger meters, a pipe cutting and threading machine, speed lathe, two small lathes and one large one, two drill presses, a machine for sharpening cutters of tapping machines, emery wheels and other small appliances. At the door is an overhead steel beam and trolley with chain block for lifting heavy meters from the truck which brings them onto a hand truck, while another is installed over the large meter testing machine to lift them from the hand truck into place for testing.

In testing the meters up to 2-inch, the water passed is weighed in tanks resting on platform scales; but the water used for testing the large meters is run into a tank ten feet high holding about 500 cubic feet, the amount entering being measured by a connected gauge glass graduated to read directly in cubic feet.

The small meters are tested with full opening, ¼ in., ⅛ in., $\frac{1}{16}$ in., and $\frac{1}{32}$ in. openings, and the large meters down to ⅛ in. opening. In testing the small meters the regular practice is to test them with full stream, ⅛ in., $\frac{1}{16}$ in. and $\frac{1}{32}$

in. opening, running 10 cubic feet, 1 cubic foot and 0.1 cubic foot respectively. The regular practice is to test each ⅝ in. meter as soon as practicable after it has registered 100,000 cu. ft., which is termed a "round."

During 1925, 7740 meters were brought to the meter shop (in addition to about 4,000 new meters tested before installing); of which 2191 were brought in when reported by meter readers as "not registering," 1,915 had completed a "round," 1,232 were from temporarily discontinued services (tested and put in shape for installing again), 904 were frozen, 709 were leaking, 269 had burst by water-hammer pressure, 71 were noisy, 155 were replaced by larger or smaller ones; while other reasons were—poor pressure, defaced, reversed, glass broken, counter cloudy, damaged by fire or hot water, and a few other miscellaneous causes.

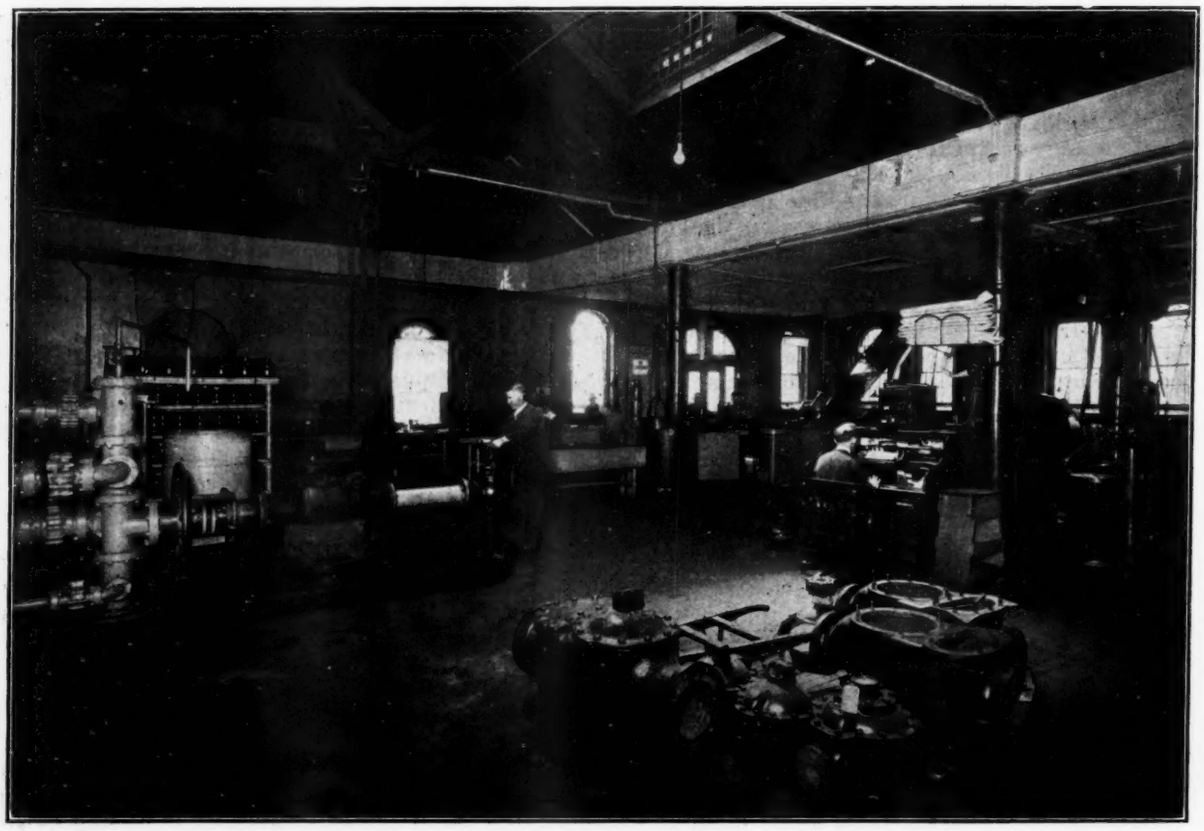
A truck makes the rounds of the several district offices and collects the meters for the shop. Each meter when brought in is accompanied by a "change slip" giving the name of district and number of service from which meter was removed, name and address of consumer, size, make, model and number of meter, and the reading of the dial, why removed and by whom, and number of the meter set in its place and the reading of its dial. (All dials are set at 0 when installed.) A tag is tied to the meter and accompanies it through the shop, on which are recorded the number of the meter, the result of the accuracy test when received, that when repaired and ready for installing, any new parts used, and the date. With 25 or 30 meters going through the shop every day, some such system is necessary.

Parts of all standard sizes of the several makes of meters (only two or three makes are used by the company) are kept in a stock room adjacent to the shop.

In some cases the consumer is charged for repairs, as when the meter is frozen, is damaged by hot water, improper treatment, etc. In such case a card is filled out recording the meter number, index reading, defects, material and labor used in making repairs, result of accuracy test after repair; signed by the superintendent of meters and the foreman of the shop, and sent to the accounting department for billing.

Twelve men are employed in the meter shop, which is in charge of F. M. Boese as foreman. George Lebold is superintendent of the meter department.

For every meter placed in service there is a meter record card on which is kept the history of that meter, which is given a number by which it is known during its life. On the record card are entered this number, the size, kind, date purchased, test, maker, cost and sizes of spuds. Then, for each service on which it is used in the future there are recorded the date set and removed, by



VIEW OF METER SHOP, LOOKING TOWARD MAIN EN TRANCE
At left, testing 8-in. meter. Center background, testing machines for small meters. At right, drill presses. In foreground, large meters ready for testing.

whom, index reading and the location and service number. On the back of this card are recorded, each time the meter comes to the shop, the date "in" and "out," index reading, cause, work done on it in the shop, cost of this, and accuracy test.

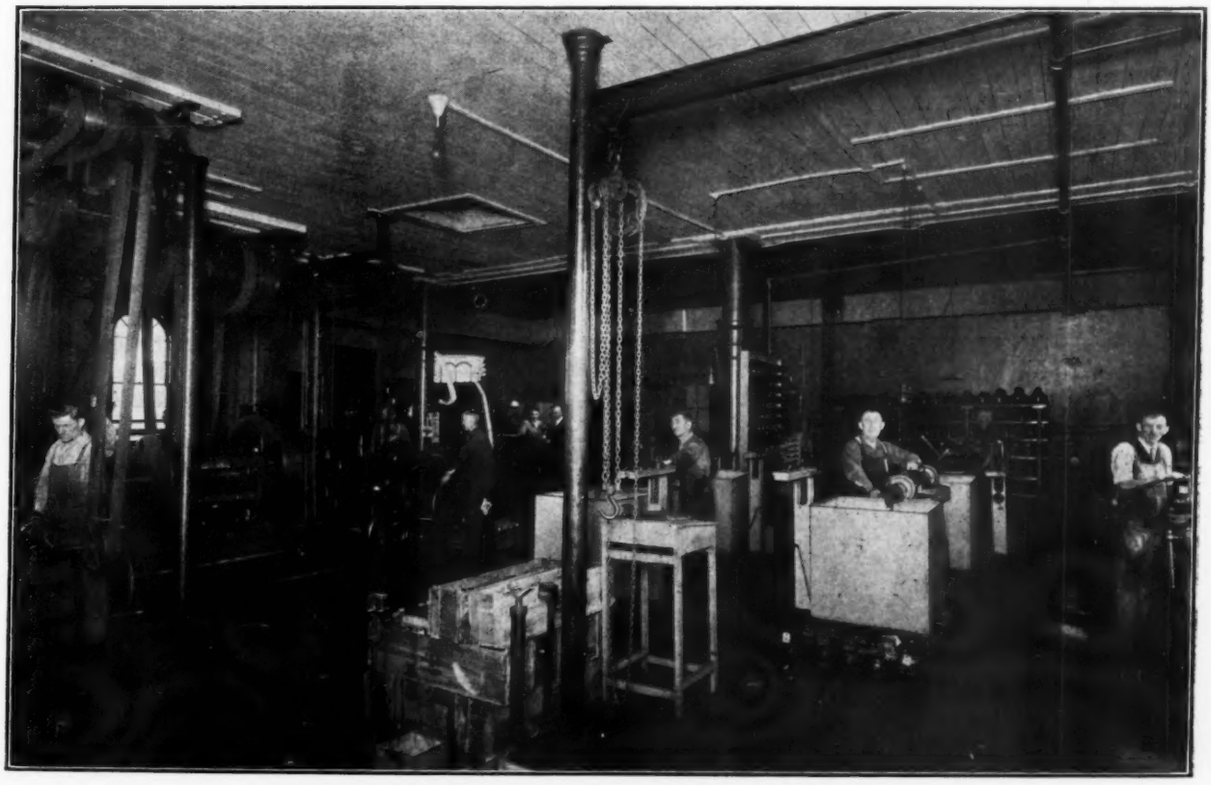
All services are metered. Even sprinkling wagons (what few are left) carry 2-in. Gem meters through which they are filled. The only exceptions are fire hydrants, both public and private; municipal flushing of sewers and streets, and building construction, which are sometimes metered and sometimes not. Fire hydrants pay $10 per year to cover interest, taxes and maintenance costs; sewer or street flushing, 8 cents a minute—$1.60 minimum charge; sprinkler connections, $45 a quarter for 3 in., up to $200 for 8 in. Water for building construction varies with the frontage, number of stories, and depth—twice as much for brick or stone as for frame.

Meter rates include a service charge of $1.60 per quarter for 5/8 in. up to $1500 for 30 in.; and a consumption charge on three different schedules, according to whether pumping is necessary. These rates vary from $1.40 per thousand cubic feet to $2.40 for the first 40,000 cu. ft. per year; $1.30 to $1.70 for between 40,000 and 400,000; and $1.20 to $1.50 for between 400,000 and 4,000,000. There is also a public fire protection charge of 0.83 cent per inch diameter per foot of main, in addition to the nominal fire hydrant charge of $10 per annum. This schedule of fire protection charges encourages the closer spacing of hydrants.

SERVICE DEPARTMENT

The service department, in charge of J. E. Eisele, assistant superintendent, is now installing services at the rate of 45 to 52 a day which will probably bring the May record ahead of that for April, 893 new installations, which was a record to date. During 1925, 5696 new service connections were made, of which 3352 were for new consumers and 2344 were connections carried to the curb opposite vacant property under municipal orders, anticipatory of permanent street improvements. In addition, old lead service pipes in streets to be improved to the number of 1225 were replaced with brass service pipe. In this connection, it is of interest to note that this company probably has installed more brass service pipe than all other companies in the country combined, having used nothing else for the last three years for 3/4-inch and 1-inch services. Last year 102,015 feet of brass service pipe was installed, representing a total installation cost of $168,161. For 2-inch services and larger, cast iron pipe is used. No galvanized services are allowed between the main and the meter. Lead pipe is permitted if the consumer desires, but the majority of them continue the service from the curb box to the meter with brass pipe.

Recently the company has inaugurated a practice, where houses are close together, of carrying a 1-inch branch to the curb, where a wye is placed and two 3/4-inch pipes carried to the two nearest houses. In making a service a Mueller tapping machine is used for one-inch or smaller



VIEW OF METER SHOP, LOOKING FROM MAIN ENTRANCE

At left, large lathe and other machinery. Center, testing machines for small meters. Right, bench for repairing small meters. Right foreground, trolley for handling large meters at testing machine

and the corporation cock is usually placed on the top half of the pipe. A lead gooseneck 20 inches long already made up in the company's shop, containing a female coupling on each end, is then set, one end screwed on to the corporation while the other end receives the end of the brass service pipe.

In making up the lead goosenecks with brass end fittings, wiped joints are not used; instead, the lead is cupped out, the specially designed coupling is set in the cup, and solder is run in. The connections are all tested to 500 pounds pressure and hammered while under pressure. The device, originated by the company, enables two men to turn out 900 connections (1800 joints) in a month, with a marked saving in cost and better results than with wiped joints.

This department operates five 1½ ton and 2 ton trucks for carrying the men, pipe, tapping machines, and various material and appliances required.

Part of the territory covered by the company contains rock close to the surface and considerable drilling and blasting are necessary in laying both mains and services. For this and other purposes, the company operates two air compressors and expected to install a third before the end of May. For short jobs such as service connections, a small compressor mounted on a Ford truck is used, but the truck has been found too light and the compressor is to be mounted on a Mack truck. These and two other compressors are used for such pavement and rock excavating as may be needed by any of the several departments.

SERVICE REPAIRS

The inspection and service repair department has five cars for carrying the equipment and materials required in its work to the various districts. Its chief work is in renewing old services (which includes new corporations and new curb cocks and boxes), replacements (replacing brass pipe for old service pipe); and changing services because of enlargement of size; also repairing curb cocks and boxes and repairing leaks in services outside of the curb, cleaning out clogged services etc. Thirty-five men are employed in this department on this work. In addition to the work just mentioned, these men also do occasional odd jobs for other departments where it is more convenient for them to do so, such as repairing a leak in a main while repairing a leaky service at that point. They also made about 800 connections of new curb cocks to the service pipes between the curb and the property, which work it is up to the owner to have done and for which a nominal collection is made. Last year this department made 1123 renewals, 300 replacements, 105 enlargements, repaired about 1000 curb cocks and the same number of service leaks and cleaned out 550 services. In the latter work, a ball of white bread is used, being forced through the service in the same way that some companies have used a small wad of paper.

There is a leak inspection gang of four men, which is continually employed in looking for leaks in both mains and services. They cover the entire system in regular routine work, making a circuit two or three times a year. In this work, they rely almost exclusively upon the aquaphone, using this on curb cocks and fire hydrants, while for locating a leak in the main they drive a rod down to the main and apply the aquaphone to this, repeating this until the increasing loudness of the sound determines the approximate position of the leak. G. F. Ziegler is chief of the inspection and repair department.

Four cars are used by the paving department, which is in charge of E. H. Paling as foreman. These gangs use a concrete mixer and carry with them concrete aggregates, cement, and tar and a tar heating kettle; also one gang carries tools and materials for repairing earth and macadam roads.

AUTO REPAIR DEPARTMENT

The auto repair department is in charge of Joseph F. Paris, who, with four assistants, keeps in repair and performs garage services for the 58 trucks. During January and February all these tucks are overhauled and painted, and they are kept in good condition during the balance of the year. This force does all the repair work and painting needed; using the lathes and other machinery in the meter shop when necessary.

NEW COMPRESSOR MOUNTED ON TRUCK

The majority of the small, service trucks are Fords, and it is the practice to trade these in for new ones at the end of two to two and one-half years. A spare rear end, a spare front end and three spare motors are kept always on hand for repairing Ford trucks. In case of a breakdown, the spare rear or front end or engine is exchanged for the damaged part and there i

there is no delay in putting the truck immediately back into service. The damaged part is then brought to the shop and put into first-class condition to be used again when the next occasion shall arise.

Among the equipment maintained, in addition to the trucks already mentioned, are four moderately heavy ones for hydrant service, these carrying spare hydrant parts, caps, nozzles, expanders and taps for rethreading hydrant nozzles, caps and hose couplings (all hydrants are now on the Fire Underwriter's standard thread, but any which are found not to be so are adapted to this standard). The latest addition to the truck family is a 2½-ton White chassis carrying a 160-foot Ingersoll-Rand compressor which will be used for breaking up pavement and drilling rock on jobs where such work will require only a few hours' service. This truck has a crew of two men, the driver operating the tools also. It has a capacity to operate two drills, and the equipment also includes two spades, and two pavement breakers, with two 25-ft. lengths of air hose. This truck, like the others belonging to the company, is governed down to a speed of 20 miles an hour. In a short time, the company expects to have in service a 210-ft. compressor mounted on a trailer, which will be used for pavement breaking and rock drilling where the compressor will work on one job for several days at a time.

The general officers of the company include Nicholas S. Hill, Jr., president (succeeding Robert W. de Forest in March of this year); Hamilton F. Kean and Henry L. de Forest, vice presidents; and Earle Talbot, secretary-treasurer. D. W. French has for 42 years been manager of the company and is also one of the directors and Mr. Talbot also serves as assistant general superintendent.

Meters in Haverhill

The 1925 report of the water commissioners of Haverhill, Mass., states that of 5,041 meters on house services, 1,239 used more than the minimum rate allowance, the excess bills amounting to $820 and ranging from 48 cents to $92. Of these excess bills 706 were for $5 or less. Meters are in service on 69.6 per cent. of all services.

Collections appear to be remarkably complete. At the end of the year, only one water bill remained unpaid, this amounting to $68.04. No services were shut off during the year for non-payment.

Water Taste from Hydrant Oil

In discussing a paper read before the Institution of Water Engineers (England) by John C. Thresh and John F. Beale dealing with the solubility of lead and copper in water, effect of chlorine, etc., W. Paterson (London) told of two instances of taste due partly to chlorine. In one case, water had been chlorinated for some time but no taste had been noticed until after the first rain which washed over newly tarred roads into the river from which the supply was taken, thus supplying the phenol which, combined with chlorine, is generally recognized as a source of tastes.

In the second case, complaints of taste were received from various parts of the city and it was noticed that they did not come from dead ends of the mains and that they disappeared very shortly. Fortunately, the engineer was a particularly observant man and noticed that the occurrences of taste coincided with the testing of fire hydrants in the various districts. When testing the hydrants, it was customary to oil the various parts and it was found by analyzing the oil used to lubricate the spindles that phenol products were present and were undoubtedly responsible for the taste given to the water.

Architectural Treatment in Water Engineering*

Desirability of effectual architectural treatment for dams, gate towers and other structures. Examples from British and American practice. Pleasing appearance worth the small additional expense.

By Prof. J. Husband, M.Inst.C.E.

Large masonry or concrete dams are structures of sufficient magnitude to constitute dominant features of the landscape. They are, moreover, frequently situated in localities of considerable natural beauty, which is further enhanced by the creation of a lake where none previously existed. Such large dams furnish ample opportunities for the display of architectural effect. Being works designed to endure for a long period of time, they are usually faced with good quality stone, and the majority possess accessory constructive features, such as bridges, overflows, tunnel outlets and valve towers, all of which demand sound and effective architectural treatment if they are not to become permanent eyesores. The minority are plain overflow dams, presenting an unbroken wall of masonry with no opportunity for relief from crest to base. Such rely for effect on mass pure and simple. It will be at once apparent that those dams in which the overflow is conducted down a separate by-pass instead of down the face of the dam, as also those which accommodate a roadway over the crest and are provided with valve towers for regulating the discharge through the dam itself, offer the greatest facilities for architectural effect.

The crest of a dam which is not required to carry a roadway or to act as an overflow may with advantage be provided with a bold coping and cornice, relieved by consoles or dentils, and carried on dwarf arches with piers merging into the sloping downstream face. This method, with slight modifications, is followed with excellent effect at the Furens, New Croton and several

* From the presidential address of Prof. J. Husband before the Junior Institution of Engineers, England.

other dams. At the Elephant Butte dam, corbelled arches alternating with highly relieved pilasters realize an equally satisfactory effect. The finest architectural results are achieved in overflow dams which accommodate a roadway along the crest. The overflow is then bridged by a long viaduct supported on piers or by one or more longer spans. One such example—the bridge over the Ashokan reservoir spillway—has already been mentioned. Another admirable example is furnished by the architecture of the Roosevelt dam, where the downstream face, valve towers and spillway bridges are all treated in a severely temperate style, with details soundly proportioned and with an absence of unnecessary ornament. The New Croton dam provides another example of plain but well-proportioned, massive architecture. Here the line of the dam is straight, and the spillway bridge a single span in steel.

Many gravity dams are more or less strongly curved in plan, and regarded from the purely aesthetic point of view, a curved dam with the roadway carried on numerous small span arches probably presents the maximum of possibilities for successful architectural effect. The convex face presented to the water suggests increased stability, even though the dam may not be acting as an arch. The numerous arched spans introduce a pleasing repetition of detail conducive to a generous appreciation of scale. Even where the upper viaduct is devoid of architectural detail, as in the Cray dam belonging to the Swansea Corporation, the effect is pleasing. This dam is straight, and the upper viaduct and face of the dam built in blue brick. The arch rings and piers are plain to severity, but the well-placed cornice and parapet suffice to confer on it distinct architectural merit. The Vyrnwy dam offers a striking comparison. Built of dark slate-colored stone, an appreciable amount of architectural detail has been introduced with an excellent result in return for the increased expenditure. The face of the viaduct is boldly relieved by pilasters and capstones, spring from robust buttresses planted on the sloping downstream face. The monotony which might have resulted from an excess of repetition on so long a dam is pleasantly interrupted by the two groups of square towers terminating the overflow section. The cornice, springing courses and capstones are heavily rusticated, in keeping with the general massiveness of the structure, and the rectangular window slits in the towers harmonize with the parapet. The general impression which a view of this work creates is one of rugged grandeur, solidity and strength.

The Craig Goch dam, in the Elan Valley, never fails to elicit universal admiration. Built on a strong curve and somewhat less rugged in detail, the distinctive impression created is rather one of grace than massiveness. The detail treatment is not dissimilar to that of the Vyrnwy dam, but is of a more softened tone. An equally well designed valve tower furnishes a pleasant break in the roadway, this feature at Vyrnwy being some distance upstream of the dam. Whilst in the Elan Valley, a view which illustrates the extent to which the original beauty of a landscape may be enhanced by the presence of tastefully designed works and the creation of a large expanse of water, is that of the viaduct over the submerged dam of Careg Ddu, together with the Focl valve tower. One other example may be cited. The Alwen dam of the Birkenhead Corporation is curved in plan, is shorter than the previous example, and is faced with concrete blocks in place of masonry. It suffers by comparison by the absence of arches beneath the roadway, which is here carried on a concrete slab, and further in having a railed instead of a masonry parapet. The monumental tower appears also to lack a blocking course above the strongly projecting cornice. Needless to say, much less money was expended on this dam than on those above mentioned.

It is natural to pass from the architecture of the dam to a brief consideration of that of the valve towers. The valve tower of a large dam is usually its most prominent feature, and further is frequently a dominant object in an extensive landscape. It is very desirable, therefore, that exceptional care should be bestowed on its exterior appearance. Great ingenuity and artistic ability have been expended on most of these structures. The dressing of the masonry and architectural treatment should necessarily be in keeping with that of other portions of the dam. Intricate or detailed ornament is out of place in structures of such magnitude. The distinctive forms must be executed on a bold scale if they are to preserve their character against the assaults of time and weather. Hence, there has been developed what, for want of a better name, may be called a megalithic style of architecture in connection with these massive structures. Many of them exhibit the characteristics of some well-established style, but present them on a scale not habitually associated with more normal buildings. Thus, one encounters towers rising to heights of 200 feet or more from base to summit. Few finer examples exist than those of the Derwent and Howden dams. These magnificent piles, simulating Norman keeps, convey an impression of majesty, strength and defiance to attack by time and storm seldom equalled. Individual details of their architecture may be open to criticism by the pedant, but any such trifling defects are readily forgotten in the contemplation of these impressive monuments.

The Vyrnwy tower, in which the water is strained prior to its entry into the Hirnant tunnel, has a total height of 170 feet, of which 110 feet rises above top-water level. It takes the form of a circular tower, with an offset turret stairway capped with high-pitched, pointed roofs and dormer windows in a style more usually met with on the Continent than at home. Rising from the lake, with its short connecting bridge, it irresistibly recalls some mediæval keep. It is unique in style as regards this country, and harmonizes perfectly with its surroundings. It is situated

sufficiently far from the dam not to clash with its different style of treatment. The two valve towers incorporated with the dam are generously designed in a massive style well in keeping with the dam and forming desirable breaks in its length.

The gate tower of the Lahontan dam is typical of recent American practice. This is an earth dam 118 feet in height, and the outlet tower, constructed in concrete, has a total height of 150 feet, and is connected with the bank by a suspension bridge of 220 feet span. It presents a severe contrast to the monumental styles affected in this country, but is still a satisfactory example of utilitarian architecture.

Let us now turn to the consideration of a few lofty water towers. These again, of necessity, frequently occupy elevated and prominent positions. One of the most successful architectural examples is probably the Norton balancing tank on the Liverpool aqueduct from Lake Vyrnwy. This tower, 115 feet in height, supports a circular tank 80 feet in diameter and 31 feet deep in the centre. The masonry is built in new red sandstone, the treatment being distinctly classical. This tower is a conspicuous and impressive monument, standing on Norton Hill, about three miles south of Runcorn. The distinctive color of the stone adds very considerably to its effect. Naturally, it is seldom that funds are forthcoming for the erection of tanks in a style sufficiently imposing to rank as models of architecture. Within recent years, the great majority of these structures have been put up in concrete, and we are all familiar with the bald appearance of the stilted rectangular columns supporting a square, octagonal or circular tank with little or no attempt to produce a pleasing result. That such a result is achievable, however, is evident from an inspection of the concrete tank at Newton-le-Willows. The unusually large number of columns here contribute to the enhanced appearance, but in tanks supported on eight or more pillars a vast improvement may be effected at comparatively little additional expense by filling in the interspaces with light screen walls suitably relieved. A highly successful example of this form of treatment is the Saint Charles tower at Nancy, which, without the screen walls and window openings, would entirely lose its distinctive merit. Another excellent example in masonry is the water tower at Calbe, in Germany. The water tower at Lincoln is another eminently satisfactory architectural structure of this type. This tower being in the near vicinity of the cathedral and a relatively massive erection, it was very desirable it should be given a distinctive architectural character. It is 56 feet square outside, and 117 feet 6 inches high. The inner tower carrying the tank is of brickwork, circular in plan, with an outside fascia of brick, square in plan and faced with Ancaster stone. The quoins and lower portion are of tooled stonework, having the panels filled in with rock-faced rubble. Below the parapet is a deep frieze of checkered fleur-de-lis, relieved by central sculptured panels supported on projecting corbels. The design was prepared by Sir Reginald Bloomfield, R. A., and is handsome, dignified and very appropriate to its situation.

Reference to a few of the architectural works associated with the Catskill water supply for New York shows that careful regard is being paid in America to the desirability of erecting permanent waterworks structures which shall have a distinct claim to architectural merit.

On most engineering works of the magnitude and class here considered, the proportion of additional expenditure on architectural detail necessary to a satisfactory artistic appearance is relatively small compared with the necessary utilitarian expenditure, yet it is generally on this final but all-important item that so-called economy is practised, often with disastrous results. The blame is not entirely on the engineer. The authorities who are responsible for the acceptance of tenders and choice of designs are occasionally but indifferently equipped for their task, and might achieve more powerfully by the exercise of a little modesty in seeking professional advice from very obvious sources.

Garbage Handling in Minneapolis

The incinerating plant in which the city of Minneapolis disposes of its garbage is several miles from the thickly settled part of the city. The method of handling is that now recognized

MINNEAPOLIS GARBAGE TRANSFER

as generally the most economical—using one type of conveyance for collection and another type for the long haul. In some cases the collection is done by comparatively small vehicles, which, when filled, are coupled into a train of several units and hauled by a tractor. In this case, the same principle is carried out by removing the body from the collecting vehicle and placing several such bodies on the platform of a large truck for the long-distance haul. One-ton motor trucks are equipped with removable steel tanks for collecting the garbage. These trucks then come to a central transfer station where a crane lifts the steel tank from the truck body and transfers it to a large heavy-duty truck, which carries seven tanks at a load. The tanks are lifted by means of four hooks, one near each corner. After the loaded tank has been removed, an empty one is put on the one-ton truck in its place and used for collecting another load.

Vialog Records of California Roads

Representatives of the California Highway Department make field inspection of work under construction at frequent intervals, and at yearly intervals after the road is completed to enable it better to judge the suitability of the type and design under known traffic conditions. These inspections consist of a vialog record of the project, a crack survey and the noting of individual items of interest. Rate of smoothness from the vialog record indicates the resistance of the pavement and its foundation to displacement. The crack survey establishes the normal interval between cracks and indicates the value of designed joints in preventing injury to the pavement from expansion or contraction.

As a method of comparing the riding qualities of pavements, the vialog has proven an invaluable aid to the department. It is stimulating interest among contractors as well as engineers in the effort to secure smooth pavements. Smoothness is not only a welcome convenience to the traveling public, but is also of vital importance to the life of a pavement. *Smoothness eliminates impact, which is the greatest enemy of any type of pavement.*

Portland cement concrete pavements constructed in 1925 ranged from 6.4 to 43.0 inches of roughness per mile. The general average was 14.3 inches.

Asphaltic concrete pavements constructed in 1925 ranged from 18.9 to 90.6 inches of roughness per mile with a general average of 33.2 inches.

The general average of all pavements constructed in 1925 was 18.8 inches as compared with a record of 22.2 inches per mile for 1924.

Where constructed shoulders were of sufficient width to carry a vehicle, a vialog record was taken and included in the general average.

Pavement Maintenance in Moline

City operates its own portable asphalt plant for making three thousand yards of patches a year. Cost of this and other street work met from municipal wheel tax. Rounding curb comers.

By C. C. Hermann

The city of Moline, Ill., has about 70 miles of pavement, and R. M. Benell, the city engineer, has calculated from the records in his office that repairs have run about 43 square yards per mile, or a total of 3,000 yards a year, for the past three years; this in addition to repairing cracks which occur, particularly in concrete.

It has been the practice in the past to contract this patching at a cost of about $2 per yard, but the city now does its own patching at about half that figure, the patches being from 1 inch to 3½ inches thick. For this purpose a portable asphalt plant was purchased from the proceeds of the wheel tax the first year this was collected.

A municipal wheel tax is authorized by the state laws, it being stipulated that it shall not exceed eight dollars for an automobile of less than 25 horsepower (N. A. C. C. rating), with higher rates for greater horsepower; and that the proceeds must be applied to the upkeep of the city pavements. In fixing its tax rate, Moline carefully budgeted its requirements and found that $3 per car up to 25 horsepower would meet its requirements. Fully 90 per cent of the automobiles in the city come under this rate. The revenue from this tax last year was $18,000 and is expected to be about $20,000 this year.

Mr. Benell states that he has yet to hear of the first real objector to the city's wheel tax; on the other hand, numerous compliments have been received on the manner in which the city is utilizing it. In explaining this he says: "The average city property has a 40 foot front. In this city the cost of paving to the property owner is $6.00 per front foot, which is 25% less than the country average. The property owner must invest $240 for paving in front of his property. The average life of asphalt paving is 20 years. The property owner must not only pay for the initial paving but he must set aside an annuity of $6.52 at an interest rate of 6% in order to meet the cost of replacing the paving on the basis of the same charge at the end of that time. If, however, the paving can be made to last 30 years the annuity at the same interest rate need be but $3.04 per year. In other words, by increasing the life of the paving 50% we automatically reduce the yearly charge 53.2%.

"The property owner knows, and the city budget will substantiate, that the ordinary

sources of income are insufficient to bear the burden of paving repairs and at the same time extend the present mileage of pavement. Some other means must be taken in order to reduce the depreciation charge of the property owner and at the same time reduce the depreciation charge for the city in general. The wheel tax offers this solution."

The wheel tax is used not only for making repairs but also for substituting curb corners with long radü for the present short-radius ones.

The tax payers see these improvements and appreciate that they are receiving their money's worth in decrease of pavement depreciation and in permanent improvements at street intersections; and therefore against this tax, at least, they have no complaint to offer but only approval.

THE ASPHALT PLANT

The city portable asphalt plant is shown in action in figure 1 and in the process of being moved to another job in figure 2, The plant is provided with a 150-gallon melting kettle having a hinged cover. There are cement and sand bins of 4 cubic feet capacity and a crushed stone bin capacity of 1 yard. A barrel rack is provided above the kettle, where the waste heat of the combustion chamber can melt the asphalt in the barrel and eliminate the necessity of breaking the barrel away from the asphalt which is the general practice and which constitutes a mean job in itself. All materials are carried in bins around which the products of combustion from the combustion chamber pass, thereby warming the material to the desired temperature of 320 degrees.

In operation, four men are required besides the driver. A team transports the apparatus from one place to another, besides hauling all materials to the plant, and hauls away the refuse chipped out of the pavements.

One of the important advantages of this portable repair outfit is that the asphalt patch is applied at the proper temperature. Where a central plant is used in repairing streets, a load of the material is sent out, when perhaps the first repair may not require more than a few square feet of new surface. So long a time is then consumed in going from one patch to another that the temperature of the material, before it has all been used up, falls far below what it should be to produce an efficient repair. It is used at this low temperature, however, rather than return for a fresh hot batch, to the detriment of the repair. With the portable plant the temperature of every patch may be maintained at the optimum temperature and this goes a long way toward maximum life of the pavement.

FIG. 2—REPAIR OUTFIT BEING LOADED WITH MATERIALS
Additional material in dump wagon pulled behind

The temperature control consists of a damper in the forward and rear stacks which may be adjusted so that the aggregates are heated properly as well as the asphalt. When the proper temperature has been obtained the aggregates are discharged upon the mixing board at the rear, followed by the asphalt, where they are thoroughly mixed and made ready for the application.

The plant is left out on the job over night. Everything is locked up. All tools slip into the mixing board which raises up against the rear and is locked. The bin doors and the fire door are locked. There is a 600-pound coal bin on the front beneath the seat, which also is supplied with a lock. Every tool has a place on the plant and is kept in its place.

The seat is the only wooden part about the plant; everything else is steel. The wheels have roller bearings. The team is used at times to move the plant from place to place, at other times an automobile or tractor moves it around. For very short moves the men push the plant along, as it moves very easily and can be handled very nicely with four men.

The plant is left on the street at night with all doors locked and the fire banked. The next morning the fire is started up and by the time the laborers have a hole cleaned out the operator has the asphalt ready to pour.

The city has had the plant for three years and

FIG. 1—REPAIR OUTFIT PREPARING TO MAKE PATCH IN ASPHALT PAVEMENT
Heated stone has been drawn from one bin and heated sand is being drawn into measuring box from the left-hand one. The third man is taking out limestone dust. These are mixed in the pan and asphalt then added

has spent nothing on it for repairs; and Mr. Benell states that it paid for itself the first year and will last for years yet. The plant cost $3,500. Three thousand yards of asphalt were laid the first year at a total cost of $3,000, whereas the same amount of repairing by contract the year before cost $6,000.

In addition to asphalt patching, there is considerable crack work to be done each year. By means of a sharp edged tool the dirt in the cracks is loosened up and is then blown out by an air blast. Heretofore a hose was attached to the exhaust pipe of the street automobile and used for this purpose; but while this has served very well so far, the city is buying a portable air compressor which will be used for the purpose this year.

ROUNDING CURB CORNERS

The standard radius for curb corners was formerly 10 feet where two streets intersect and 3 feet at alleys. With automobile traffic these are dangerous, and a car turning the corner at fifteen miles uses the whole 25 feet width of pavement.

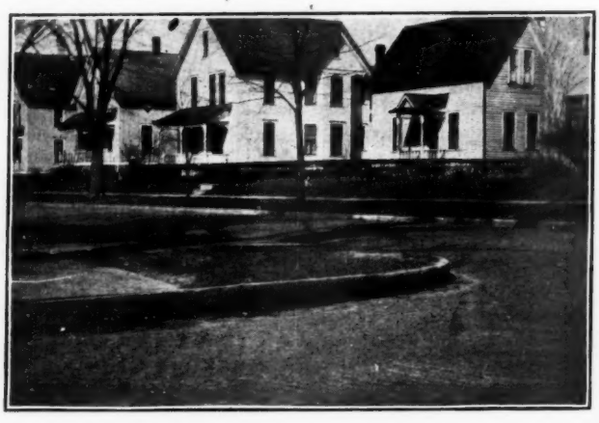


FIG. 3—CURB CORNER NOT YET FLATTENED

Therefore the standard radius has been increased to 15 feet (more if possible) at streets and 10 feet at alleys. The old sharp corners are being changed to this as rapidly as possible, the most dangerous corners being taken first. For this the city purchased a small portable concrete mixer and is doing all the work with street department employes. The average cost, including removal of old curb, excavation, and laying new pavement and curb, is $100 per corner.

Paving Brick Varieties

The Standing Committee on Paving Brick Simplification functioning with the U. S. Department of Commerce, held its annual meeting in Washington on April 1st. As a result of its deliberation, no changes were made in the four varieties recognized as standard.

A survey of shipments in 1925 showed that of 353,600,000 brick, representing 96 percent of the tonnage capacity of the industry, 74.2 percent were in the four recognized varieties. The 3½x4x8½ plain wire-cut descreased from 11 percent in 1924 to 5½ percent in 1925, while the Dunn wire-cut-lug increased from 6 percent to 7 percent.

In 1924, the recognized varieties constituted 82.1 percent of the total shipment, the decline in 1925 being due to the increased demand for thinner brick. The 2½x4x8½ plain wire-cut increased from 2.7 percent in 1923 to 8.9 percent in 1925. The committee carefully considered the advisability of declaring this size a recognized variety, but the rules provide that a variety shall not be so designated until its shipments for three successive years have amounted to at least 5 percent of the total.

Longitudinal Center Joint in Concrete Paving

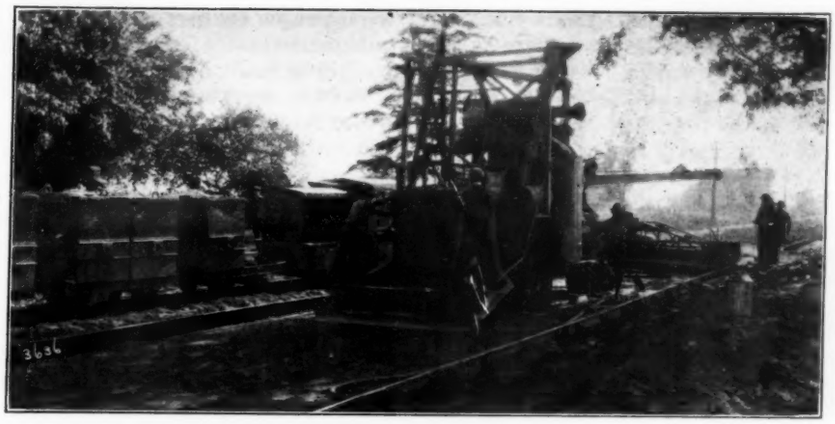
It is rapidly becoming general practice in constructing a concrete pavement to place a longitudinal joint down the center of the pavement. In order to avoid the unsightly appearance of a crooked joint, pains should be taken to place the plates, forms or other contrivance for making the joint, exactly parallel to and halfway between the side forms.

The ordinary method is to set a thin metal plate vertically in the center line just behind the mixer, which necessitates placing only a few

FIG. 4—CURB CHANGED TO FIFTEEN FEET RADIUS

feet at a time and not only makes more difficult the exact alignment of the center joint, but also interferes somewhat with the placing and levelling of the concrete as it is discharged from the mixer. This was avoided in work done in Illinois last year by the Henkel Construction Company. In this work the center plate was set for two or three hundred feet ahead of the mixer and, in order that the skip when lowered to receive its charge should not rest upon this plate and drive it into the subgrade, two timbers were bolted to the underside of the skip, one on each side of and parallel to the center plate; these timbers being of such thickness that when they rest upon the subgrade the bottom of the skip just clears the center joint plate.

It would apparently be impracticable to adopt this plan where the aggregate is being brought over the subgrade by means of trucks; but in this case the aggregate was brought by an industrial railway. This plan would also seem to be practicable where the aggregate is brought to the skip in wheelbarrows, but this practice is now almost obsolete.



UNLOADING BATCH BOX FROM TRAIN TO MIXER

Combination Haul vs. All Truck Haul on Road Work

Demonstration of advantages of combination haul plant in bad weather and sandy subgrade

By T. J. Weidner*

The combination of a sandy subgrade and wet weather gave an opportunity to emphasize the advantages of the combination haul plant under such conditions on one of the jobs which our company did last season in Ashtabula County, Ohio.

The particular work in question was twelve miles of sixteen-foot concrete road with an average thickness of seven and one-fourth inches.

The job was not awarded until late in July, and, inasmuch as it was desired to complete as much of the work as possible before the close of the season, it was decided to put two outfits to work.

On August 10th we started at one end of the job with our combination haul plant.† A 21-E paver was used and materials were hauled on trucks in batch boxes from the central proportioning plant to a transfer, where the boxes were lifted off the trucks and placed on narrow gauge cars for delivery to the mixer, past the green concrete. We could transfer a box from trucks to cars or vice versa in a little less than one minute.

The transfer device which we used was entirely home made. It was a design of one of the members of our firm, L. J. Westland, who acted as superintendent of the work.

At the beginning of operation, the mixer started at the transfer point and about two miles were laid, when the transfer was moved ahead as far as the concrete was cured sufficiently to allow trucking over it. As the work progressed, this transfer was continually moved ahead so as to allow trucking over the new concrete as far as it had been open to traffic.

Our haulage equipment consisted of Lakewood track, cars, and batch boxes, together with two seven-ton Plymouth locomotives. On the maximum haul we used three trains, each consisting of eight cars and sixteen boxes.

As a direct basis of comparison, we started on August 20th with another outfit on the same job. This outfit was identical with the first one as far as the subgrading, mixing, and placing equipment was concerned, but the hauling was done entirely by trucks.

A large portion of the subgrade was sandy, while in other places it was entirely of clay. Very often it was necessary to plank over the sandy subgrade for the trucks because even the light trucks would almost bury themselves, necessitating rebuilding the subgrade and even resetting the forms. The sections of clay subgrade were particularly bad in wet weather, and a great many rainy days were encountered during the time the work was in progress.

This condition of the two plants working on a job where conditions of hauling equipment,

TRANSFERRING BATCH BOXES FROM TRUCK TO TRAIN

*Secretary and Treasurer, Geo. S. Mellert, Weidner Co., Medina, Ohio.
†This plant and the transfer device were described in PUBLIC WORKS for January, 1925.

type of work being done, etc., were identical and the only variation in the plants being in the method of haul, gave good opportunity for a direct comparison of the combination haul plant and the motor truck plant under such circumstances.

It was necessary to shut all of the work down before it could be completed on account of cold weather setting in. However, the combination haul plant, which started work August 10th, completed seven miles. The motor truck outfit, which started only ten days after the combination plant, completed three miles.

In comparing these figures it must be remembered again that the conditions of the weather and subgrade were such as to make the truck haul plant difficult to operate but did not affect the combination haul plant.

There is no question but that the combination haul outfit in the majority of instances will give greater production than the truck haul outfit for the same length of time. The reason is that the combination plant, where all hauling is done over good roads and with narrow gauge, is not compelled to shut down because of weather conditions to the extent of the truck haul outfit.

Naturally, the gain in production with the combination haul plant, due to the greater time it will work, will be affected by the weather encountered and by the character of the subgrade over which hauling is done. It is true that sometimes conditions might be encountered where a truck haul plant would show to just as good advantage as the combination outfit. For instance, if a new road were being built over an old macadam base, the delays to the trucks from weather would not be so serious. Again, a season might be encountered with very few rainy days.

But, all in all, comparing one against the other for average conditions, it can be said with positive assurance that more working days per season can be expected from the combination plant.

There are certain other intangible factors which make the combination haul plant a producer of better profit to the contractor. There is a saving of material because it is possible to maintain exactly with the combination plant the required depth of subgrade. With the truck plant, the subgrade once prepared is rutted and cut up, making retrimming necessary, increasing the amount of concrete required, and adding to the labor costs. Neither is it possible to keep the subgrade as well rolled, the rolling operations being interfered with by passage of trucks.

Again, with the combination haul plant, forms once set are not disturbed by trucks crowding them up or out of line. Roads can be built smoother, with less hand work behind the finishing machine as a result, and the work can be done cheaper and better.

As a result of our own experience with trucks and narrow gauge, we are firmly convinced of the economy and advantages of the latter.

Meter Rates for Water

Analysis of rates of more than three hundred cities. Half the cities reported as 100 per cent metered. Less than 5 per cent without any meters. Wide variations found in all features of rate schedules.

Among the questions asked in our annual questionnaire sent to water-works superintendents this year were several relating to meter rates. Ten years ago we collected and published a tabulation of the meter rates charged in several hundred cities and again five years ago; and we are so frequently asked for information on this subject that it has seemed to us desirable to endeavor to keep these figures up to date by collecting similar information this year.

The questions asked were: the percentage of services metered; the maximum and minimum meter rates and the quantities of consumption to which these apply; and the average meter rate received, which was defined as being the quotient obtained by dividing the total receipts from meters by the total amount of water sold by meter. The last question was not answered in all of the replies received, probably because most of the superintendents had not had occasion to make this calculation. It seemed to us that it would be useful however, as, used in connection with the maximum and minimum rates, it would indicate approximately the percentage of users who did not pass minimum consumption limits entitling them to a rate lower than the maximum.

One of the encouraging features brought out by the replies is the rapid adoption of meters throughout the country. Of the first 300 cities replying, 51% reported their services as 100% metered, while 60% reported 90% or more of the services metered; and only 14 reported no meters in use. The average percentage of services metered, including those cities which have no meters, is 81.

During the past few years considerable study has been given by superintendents to the subject of water rates, especially meter rates, and we had expected to find that this has resulted in a nearer approach to uniformity in the practice of the various companies as to meter charges. However, the replies received to our questionnaire indicate that if anything there is less uniformity now than there was several years ago; and, of all of the various phases of engineering and management of waterworks, there would still seem to be more diversity of practice in the matter of water rates than of any other.

Not even a uniform unit of measurement has

been adopted, some charging by the 100 cu. ft., some by the 1000 cu. ft. and some by the 1000 gallons. (Since those charging by the 1000 cu. ft. were few, we have, in tabulating the replies, reduced figures on this basis to the equivalent rate per 100 cu. ft. and so entered it in the table.) An examination of the first three hundred replies received shows that 47% use cubic feet as the unit of charge and 53% use gallons. In some states there is practical or absolute uniformity among all the cities reporting, but in the majority of cases there is no uniformity found even in individual states, to say nothing of groups of states in a given section of the country.

Most cities have a sliding scale of rates—a maximum rate up to a certain consumption, followed by from 2 to 6 or 8 different rates depending upon the increasing amounts of consumption. However, twenty cities reported only one uniform rate for whatever consumption, while several others have only two rates. Some base the rate upon the cubic feet or gallons consumed per month, per quarter, per half-year, per year, and in a few cases per day. In one city the rate depends not upon the amount of consumption but upon the nature of the use, domestic consumption being charged one rate and industrial a lower rate.

An increasing number of cities are making a fixed charge, sometimes called a "meter rental" or "service charge," which is independent of the amount consumed, and add to this a consumption charge. This fixed charge usually varies with the size of the meter. Some cities have worked out a more or less elaborate system with individual peculiarities of their own. Milwaukee, Wisconsin, charges seven cents per 100 cu. ft. inside of the city, and ten cents outside of the city, this rate applying to all consumers whether large or small. In addition, there is a service charge of $2 per meter per year which is the same for all sizes of meter. This is an exception, however, since most cities regulate the "service charge" or "meter rental" by the size of the meter; although several which have graded fixed charges have uniform rates for consumption.

Inspecting the practice as to period of time on which quantity of consumption is based in determining meter rates, we find that about 51% use the month as the bases, 41% the quarter, 1¼% the half-year, 2¾% the year and 4% the day. Probably in the majority of cases this period corresponds to the frequency with which meter bills are rendered; but this is not invariable, since in some cases, at least, those employing the annual consumption as a basis of rates render bills quarterly; while of course none of those using the daily rate render bills less frequently than once a month.

While considerable variation is seen in the general plan of fixing meter rates, the variation in the rate itself is very much greater. The maximum rate, for instance, (which affects more consumers than any other in most cities) is found to vary from 7 cents per 100 cu. ft. to 60 cents, and from 8 cents to $1.50 per 1000 gallons. The two lowest rates, 7 cents and 8 cents respectively, are not really maximum rates but are the uniform rate charged regardless of the amount consumed. The minimum rates vary from 2½ to 40 cents a 100 cubic foot and from 2 to 62 cents per 1000 gallons. The ratio of the maximum rate to the minimum rate in a given city varies from one (where the rate is uniform) to as high as 12½. The average however, is about 2½ and the majority are found to lie between 2 and 3.

For convenience of comparison, we have reduced the rates and the quantities of consumption used as basis of rates to equivalent rates per 100 cubic feet and consumption in cubic feet per year; although, as stated above, different cities express them variously in cubic feet or gallons per day, month, quarter, half year or year. Grouping the maximum and minimum rates more or less arbitrarily, we find that a maximum charge of 10 cents or less is made by 6 per cent. of the cities, 11 to 15 cents by 15 per cent., 15½ to 20 cents by 22 per cent, 20½ to 25 cents by 18 per cent., 25½ to 30 cents by 18 per cent., 30½ to 39 cents by 12 per cent. and 40 cents or over by 9 per cent. The minimum rates are found as follows: 4 cents or less by 7½ per cent., 4¼ to 6 cents by 20¼ per cent, 6¼ to 8 cents by 24¾ per cent, 8¼ to 10 cents by 12 per cent, 10¼ to 15 cents by 22 per cent., 15¼ to 20 cents by 7 per cent., and over 20½ by 6½ per cent. of the cities.

The minimum amount of consumption beyond which the maximum rate ceases to apply varies from 1,800 cubic feet a year to 18 million; while the maximum consumption beyond which the minimum rate applies varies from 4,000 to 136,875,000 cubic feet. The minimum of these would seem to be even more remarkable than the maximum, being equivalent to only about 5 cubic feet per day per meter—a fairly economical domestic consumption for only one person. One of the arguments made in educating the public to favor metering water has been that there will be a minimum charge, entitling the consumer to about what the average family needs for domestic use, and there will therefore be no possibility for a user to save money by reducing consumption below what is necessary for sanitation and health. And we can see no advantage, but only more work for the office force, in reducing the maximum rate at a consumption rate less than the minimum ordinarily required for domestic use—say 750 to 500 cubic feet per month or 9,000 to 6,000 a year. One of the cities giving the limit for maximum rate as 2,000 cubic feet per year expressed this as 500 cubic feet per quarter, up to which the charge is 27 cents. The charge is then reduced by a sliding scale until at 400,000 cubic feet per quarter it reached a minimum of 6½ cents. Another city changing the maximum rate at 500 gallons per quarter, charges 30 cents up to this point and reduces ultimately to 5½ cents for all over 1,200,000 cubic feet per month. The city at the other extreme charges 16 cents per 1,000 gallons for the first 200,000 gallons a year, reducing this to a final

minimum of 2½ cents per thousand gallons for a consumption of 500,000 gallons a day

As already stated, not all the replies gave the figures for average meter rate received. (Total receipts from metered water divided by total amount registered by meters.) Eighty-three of the first 300 did so, and from these replies we have made the following general summary. The average of the maximum charges made by these cities was 32.2 cents per thousand gallons and of the minimum was 12.7 cents, the ratio between these being about 2½, the same as for the entire 300. The average rate received, including all consumers large and small, was 21.7 cents. This apparently indicates that the amount sold at the low rate to the large consumers somewhat exceeded that sold at the higher rate to the smaller consumer. However, it would require a study of the graded charges of each city to definitely decide the significance of this. An additional factor enters, in that many if not most of the cities have a minimum charge for each size of meter and in some cases the consumption itself does not reach this minimum and thus the rate per gallon or cubic foot actually paid exceeds the nominal rate. For instance, in one city where the maximum rate is 25 cents per 200 cubic feet and the minimum 10 cents, the average rate received for metered water was 27.3 cents. In some instances the figures seem to indicate that the large consumers at low rates took a considerable percentage of the supply, one city with the rates graduated from 13 cents to 4 cents receiving an average of 6 cents for the entire supply, another with rates from 16 cents to 10 cents receiving an average of 11¼ cents, etc. However, the reason for several of these probably was that most of the meters were on the services of the large consumers, only a few of the domestic consumers being metered.

Factors Other Than Dissolved Oxygen Influencing the Corrosion of Iron Pipes*

When a bright iron surface is exposed to the water of any of our public water supplies, dissolved oxygen at first has the greatest influence on the rate of corrosion, but after a film of iron rust has formed other factors become of major importance.

The saturation point of ferrous hydroxide in the absence of dissolved oxygen is very low for natural water when the pH is above about 8. This does not confirm the work of others who have used pure distilled water.

Ferrous carbonate is only very slightly soluble at the saturation point of calcium carbonate, but the solubility concentration increases very rapidly as the pH is decreased below calcium carbonate equilibrium.

Iron will not corrode to the extent of producing hydrogen gas bubbles in pure distilled water at room temperature or below even after standing for several months. The liberation of hydrogen gas is due to the presence of negative ions other than the (OH) ions. These negative ions are concentrated at the metal surface by the difference in electrical potential of the metal and the water. As a result of this concentration iron salts are formed.

The final equilibrium of iron and carbonates is a very insoluble ferrous carbonate if the pH of the solution is sufficiently high. Other salts of iron, such as the sulfates and chlorides, are very soluble and will exist only at pH much less than that formed by ferrous carbonate. When such salts are present they tend to maintain a pH of from 6 to about 7.5 against the iron surface.

Some of the iron oxides or hydroxides are very magnetic and are attracted to the metal surfaces with considerable force, resulting in a fiber formation and the building up of a very porous precipitate.

Pits with overlying tubercles start to form when the rust becomes so thick that the diffusion of soluble iron compounds to the water outside of the precipitate is retarded to the extent of allowing the dissolved oxygen zone to extend to the surface of the precipitate. Precipitation then begins to take place within the existing precipitate and soon forms an impervious or nearly impervious membrane near the outer surface of the rust. While the membrane is being formed there is considerable concentration of iron salts such as the sulfates and chlorides. Such salts are probably essential for pitting and tuberculation to continue.

Active tubercles maintain a pH near 6 on the inside next to the metal surface and dormant ones have a pH somewhat higher.

*Abstract, in "Public Health Engineering Abstracts," of article by John R. Baylis in April issue of "Industrial and Engineering Chemistry."

Engineers for Public Buildings

The U. S. Civil Service Commission is still asking for architects and engineers to be employed in connection with the $165,000,000 public building program contemplated by Congress (see March issue of PUBLIC WORKS), and has extended to June 30th the date for the close of receipt of applications for such positions, and has raised the age limit from 45 to 50 years. Information can be obtained from the Commission at Washington, D. C., or from the secretary of the U. S. Civil Service Board at the post office or custom house in any city.

Work Done by Associated General Contractors

Statistics have been compiled by the Associated General Contractors showing the amount of work handled last year by the members of that association. This totaled $2,294,000,000, divided as follows:

Buildings, $1,595,800,000; public works (other than highways) $351,500,000; highways, $237,400,000; railways, $109,300,000.

Ripe Sewage Sludge

Discussion of Studies by the New Jersey Agricultural Experiment Station on biochemical oxygen demand of fresh solids in the course of digestion and of ripe sludge. Method to determine "ripe" sludge.*

By Willem Rudolfs and A. J. Fischer†

Studies on biological fresh solids (raw sludge) digestion carried on in our laboratory for the last four years have shown that in the course of digestion organic particles undergo apparent changes which are basically the same for all incoming mixed domestic material. The question of the amounts of oxygen necessary in the processes of stabilization is of interest both for proper sludge digestion and for the production of "ripe" sludge. In stream pollution studies the quantity of oxygen required for complete stabilization of polluted water is usually taken as a measure of the organic matter content. In the different anaerobic systems of sludge digestion all organic matter is never completely oxidized but a reduction of about 50 per cent. of the organic matter is about the best result attained with the present means. Ordinarily the reduction in organic matter is less than this percentage.

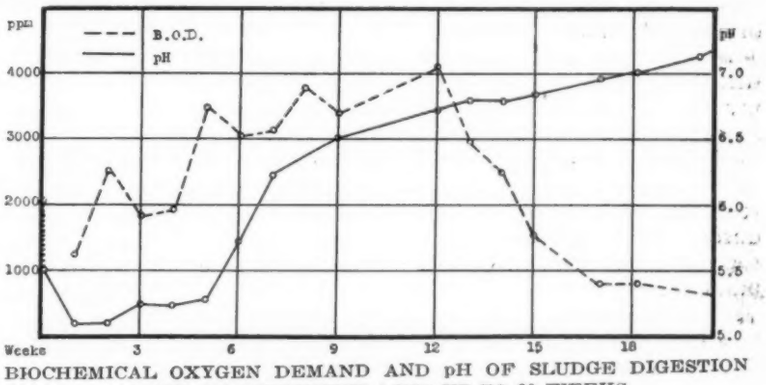
In biological stabilization, oxidation or liquefaction, at least two factors must be taken into consideration before a statement can be made regarding the oxygen requirement for a given amount of decomposing material: (1) kind of digestion, and (2) state of oxidation of organic material. The former depends upon the flora and possibly the fauna present, producing certain intermediate and end products, while the latter depends upon the progress of the course of digestion.

METHODS AND MATERIAL

The method employed by the Sewage Substation in collecting fresh solids is by hanging pails several feet below the surface in different sections of the flow compartments of an Imhoff tank. The suspended solids settle in these pails which are left for about 24 hours. The supernatent liquid is syphoned off and the fresh solids brought to the laboratory. The fresh solids used in this experiment were diluted with distilled water resulting in 1.35 per cent. total solids. This material was incubated at 20° C. and samples analyzed at frequent intervals during the entire period of digestion. No ripe sludge was used for seeding. In addition to biochemical oxygen demand tests, the samples were analyzed for total acidity, total alkalinity, total nitrogen, ammonia, nitrites, nitrates, solids, ash, and the hydrogen-ion concentrations determined. All chemical determinations were made by the junior author. From a series of such experiments only a part of one is presented in this paper to serve as an example. All figures on B.O.D. are based on 24-hour incubation periods at 20° C. It is realized that these short-time determinations may be objectionable in discussions on complete oxidation of organic material. The practical impossibility of using 5-day periods with fairly concentrated material, because of high dilutions required, led us to use the 24-hour test, especially in view of the fact that comparative figures were wanted for relative stability and some method for the determination of well digested sludge:

Method—5 cc. sludge was used, added directly to the diluting water in 500 cc. bottles. Sludge was well shaken to secure uniformity. The samples were drawn up into pipettes (tips broken off) care being taken to exclude all large gas bubbles which may be entrained.

Results—The biochemical oxygen demand figures together with the pH values obtained are presented graphically in the diagram. The typical curve for pH values found in all fresh solid digestion experiments is here again apparent. Usually fresh solids collected have pH values ranging from 6.3 to 5.9 with an average (of several hundred samples) of 6.1. Within the first few days the pH value drops rapidly until after about one week the flow limit of about 5.1 is reached. During the next few weeks the pH value remains fairly constant (the length of time depending apparently on the concentration of the solids) and from then on moving rapidly toward the neutral point and then more slowly beyond to an alkaline reaction.



BIOCHEMICAL OXYGEN DEMAND AND pH OF SLUDGE DIGESTION TANK AT DIFFERENT AGES UP TO 20 WEEKS

The biochemical oxygen demand in the samples increased with the time of incubation until, after

*Paper No. 290 of the Journal series, New Jersey Agricultural Experiment Station, Department of Sewage Investigations.

†Chief, Sewage Investigations, and Research Fellow, respectively, of Sewage Investigations Laboratory, New Jersey Agricultural Experiment Station.

Some Chemical Results Obtained in the Course of Digestion

Time	Reaction	B.O.D	Solids	Organic matter	Ash	Solids reduction	Org. matter reduction	Ash increase
weeks	pH value	p.p.m.	%	%	%	%	%	%
0	5.5	....	1.35	75.9	24.1	....	....	....
2	5.1	2560	1.06	73.3	26.7	21.6	3.4	10.8
12	6.8	4100	0.86	69.6	30.4	36.2	8.3	26.1
18	7.0	800	0.80	65.9	34.1	40.8	13.2	41.5
23	7.4	....	0.74	55.5	44.5	45.1	26.9	84.7
26	7.4	500	....	....	....	....	....	....

12 weeks, the highest point was reached. This high point occurred at the time when the material was nearly neutral. In several instances we have found that the highest point occurred at exact neutrality, pH 7.0. The remarkable sudden drop from that time on corresponds to a change in condition of the material. The putrefactive odor changes to an acid odor and the opaque supernatent liquid becomes clear. This acid odor changes later to the peculiar tarry, methane odor, typical of well digested sludge. It will be noticed from the B.O.D. curve that a series of oscillations were recorded. The significance of these oscillations will be discused elsewhere in connection with definite periods in digestion (decomposition of different groups of materials).

DISCUSSION

Before the significance of the graphs can be properly discussed and conclusions drawn it is necessary to consider the figures presented in the table.

The original material contained 76 per cent. organic matter; after 23 weeks the organic material was nearly reduced to two-thirds the original percentage. The ash content increased about 85 per cent. After 12 weeks the per cent. reduction in solids was still greater than the per cent. increase in ash, indicating partial liquefaction, which was greatest in the beginning. Six weeks later (18 weeks) the per cent. increase in ash content had equaled the per cent. reduction of solids, showing that the liquefied material had been further oxidized. After 23 weeks the per cent. ash increase was almost twice the per cent. solids reduction, indicating that practically all the liquefied material was mineralized. This corresponds to the usual rapid increase of gas production measured in a large number of instances in our laboratory.

For the first high peak of biochemical oxygen demand, results show an ash increase of about 10 per cent. With the next 15 per cent., or a total of 25 per cent. ash increase, there was a requirement of 4,100 p.p.m. oxygen. The sudden drop of the B.O.D. shortly after would tend to indicate that a reduction of about 40 per cent. of solids, or a reduction of 25 per cent. organic matter, means a certain stabilization which is fair for practical purposes.

If a percentage in ash of at least 40 per cent. and a decrease of at least 25 per cent. organic matter corresponds to a good sludge, comparative low values of biochemical oxygen demand together with some other determinations can be employed to answer the often baffling question: What constitutes a good, well digested sludge? At present, requirements for a good sludge depend often upon the man who makes an examination. Some engineers use any or a combination of conditions like odor, color, floc formation, ash content, total alkalinity, etc. However, color alone is no indication, since with certain manipulations (mechanical or chemical) intense black material can be produced which is still in the first stages of decomposition. Odor alone is insufficient since with certain chemical treatment and low temperature odor might be nearly absent from fairly fresh solids. A combination of the two factors color and odor is consequently not necessarily an index of ripe sludge. Floc formation alone is insufficient because this appears at different stages of digestion. Percentage of ash alone or in combination with the above-mentioned factors is of little value unless the ash content of the original material is known and also the percentage solids reduction; neither is alkalinity alone or in combination with color, odor and floc formation a good indication, since total alkalinity increases in the course of digestion and when digestion is fairly complete decreases again. Moreover, alkalinity varies with the concentration of material.

In the case of stream pollution the B.O.D. is taken as a measure of the organic matter content; there is, therefore, a definite relation between oxygen requirement and complete stabilization. A similar definite relation seems to exist between B.O.D. and organic matter decomposed to a fairly stable condition. Determinations of a number of ripe sludges with different concentrations of solids show that, from a practical standpoint, digested sludge has a biochemical oxygen demand of not more than 1,000 p.p.m for each per cent. organic matter in the sludge; and a well digested sludge stable enough to be drawn under ordinary circumstances, of not more than 1,500 p.p.m. for each per cent. organic matter.

Calculation of results:

$$\frac{\text{Biochemical Oxygen Demand.}}{\text{Volatile Matter on Wet Basis.}}$$

For example: a thoroughly digested sludge with 5 per cent. solids and 50 per cent. ash content should have a biochemical oxygen demand of not more than 2,500 p.p.m. by the 24-hour test at 20° C. At the same time the material should have a pH value of higher than 7.0, usually 7.4 to 7.8; this is independent of total alkalinity and serves as a very good check.

Biochemical oxygen demand, organic content and certain pH value determinations seem at the present stage of our knowledge as good a set of conditions to answer the question, "what constitutes a good, well digested sludge," as can be devised. These determinations can be complemented by physical

observations on color, odor and floc formation (case of dewatering).

In conclusion it might be stated that studies completed or nearing completion in our laboratory, on the effect of the material on the rate of sludge digestion, the effect of lime to keep the reaction at an optimum, the effect of temperature on sludge digestion and its relation to the reaction of the material, the effect of dilution and concentration of solids on digestion, throw much needed light on the relation of biochemical oxygen demand and sludge digestion.

Licensing Sewage Plant Operators

New regulations controlling licensing of operators in New Jersey. Requirement of licensing advocated for Iowa.

Two addresses by engineers of state health departments have recently reached this office, one by Hans V. Pederson, sanitary engineer for the Iowa state department of health, presented at the seventh conference on sewage treatment at Ames, Iowa; the other by Dr. H. B. Costill, director of the New Jersey Department of Health; both having as their principal theme the licensing of sewage treatment plants.

New Jersey is believed to be the only state in the country which requires the licensing of operators of sewage and water treatment plants. Regulations for carrying out the state law were adopted by the state department of health in May, 1919; and in April, 1926, considerable changes were made in these regulations, which changes were announced at the meeting of the New Jersey Sewage Works Association the same month.

The new regulations classify licenses into two main groups—primary treatment and primary-secondary treatment; and each of these is further divided into first, second and third division.

The primary treatment group includes all plants which use only primary treatment, such as Imhoff tanks, plain settling tanks, separate sludge digestion and screens. The second classification covers plants using primary treatment and also some form of secondary treatment such as chlorination, oxidizing units or combinations thereof, including activated sludge. Each group is divided into three classes or divisions—First, Second and Third—depending upon the location of the plant to be operated, the size of the installation, and the usage of the receiving waters.

Primary Treatment—First Division: Qualifications in brief are: a satisfactory knowledge of primary treatment in general, together with ability to make tests of plant treatment efficiency by means of chemical and physical analyses.

This grade is required for plants with a capacity of 2,500,000 gallons or over per day, and for all plants with a capacity of over 1,000,000 gallons per day using separate sludge digestion.

Primary Treatment—Second Division: A comprehensive knowledge of the type of plant which the candidate expects to operate, together with the ability to make tests of plant efficiency for operation control.

This license to be held by operators of Imhoff and multiple tank installations with capacities of from 250,000 gallons per day to 2,500,000 gallons per day, and operators of separate sludge digestion plants of less than 1,000,000 gallons per day.

Primary Treatment—Third Division: A knowledge of the type of plant which he is to operate including maintenance, operation and construction is required.

This license is to be held by operators of all plants not previously classified.

Primary-Secondary Treatment—First Division: Qualifications in brief are: a comprehensive knowledge of the sewage treatment processes in common use, the ability to describe and perform the standard chemical, physical and bacteriological tests, and to interpret the results of the same.

This license to be held by operators of plants with capacities of 500,000 or more gallons per day located on watersheds used for potable water supply.

Primary-Secondary Treatment—Second Division: Qualifications in brief are: a comprehensive knowledge of the type of plant which the candidate expects to operate, the ability to perform routine tests of the efficiency of treatment, and to interpret the results of standard chemical, physical and bacteriological analyses.

This license to be held by operators of plants with capacities of 5,000 to 500,000 gallons per day located on watersheds used as sources of potable water supply; by operators of all plants on or adjacent to shellfish areas; and by operators of other plants with a capacity of over 100,000 gallons per day.

Primary-Secondary Treatment—Third Division: Qualifications in brief are: a knowledge of the plant to be operated and the ability to make such tests as may be necessary for proper control. This division covers all plants not previously classified under Primary-Secondary Treatment.

Another action of the board to which Dr. Costill called the attention of the association, was an act which it was proposed to submit to the legislature, prior to which he asked its consideration by the association. This act would provide that whenever the department of health of the state, or its director, "shall cite for hearing or conference any officer, officers, member, members, or employee or employes of any county, municipality, or other subdivision of the state, in matters affecting the public health," then any party so cited who shall attend the hearing or conference shall be paid all necessary expenses of attending the conference by the county or municipality on presentation of a certificate of the state department of health or its director that he had attended the hearing or conference.

The remarks of Mr. Pederson were practically an advocacy of the adoption in Iowa of the plan of licensing sewage treatment operators. He stated that a survey of 222 municipalities in a certain section of the state showed 81 of them to have sanitary sewer systems and 57 of these operating a sewage treatment plant. Of these 57 plants, however, 31 were reported as being in very bad shape due to a lack of proper attention and very few were reported as working at maximum efficiency.

Altogether there are about 200 municipal sewage treatment plants in Iowa, and "it is safe to say that one-half of these plants are laboring under difficulties brought about by incompetent operation." Mr. Pederson suggests two reasons for this unfortunate condition; the first being that "the average city or town council fails to realize the necessity of providing a competent, intelligent and industrious plant operator to perform certain fundamental duties of the right kind and in the right way; and

the second reason is that the average council fails to provide yearly a sufficient repair and replacement fund.

"Is it expedient or good business on the part of the people of the state to sit idly by and let a perfectly good sewage treatment plant that cost the various communities from $25,000 to $200,000 become inoperative or entirely out of commission in a short period of time? A well designed sewage treatment plant adequate for a small community, if properly cared for, should last a lifetime with very little expense outside of the salary of the operator. Which is really better—to provide a competent caretaker from year to year, or to dispense with the caretaker and practically rebuild the plant at the end of ten years?"

In order to prevent the rapid deterioration and faulty operation of such plants, he suggests that a state law be passed requiring every city or town having a municipal sewage treatment plant to employ a licensed operator to look after the plant; licenses being granted by the state department of health upon a written or oral examination showing that the applicant is thoroughly informed as to his duties. He suggests that one qualification for a license be that the applicant attend two conferences of sewage treatment plant operators such as are held under the auspices of the engineering extension department of Iowa State College. (This address was made before the 7th conference of this kind.) A second suggestion is that each operator be required to fill in a weekly report card to be furnished by the state department of health giving a record of just what work has been performed by the plant during that week. A third suggestion is that a full-time sanitary engineer be added to the sanitary engineering division of the state department of health whose duty it will be to visit each municipal treatment plant in the state periodically, for the purpose of investigating the plants and advising both the council and the operator concerning what should be done to improve the operation. "An operator might be licensed and he might fill out a report card in an intelligent way, but still he may know very little about the fine points of sewage treatment. Knowing that the better a man really understands his work, the better his results will be, it is suggested that a department engineer visit each plant at least once a week in order to point out the weak spots and to take each operator into his confidence.

"Satisfactory results can never be obtained from sewage treatment plants without proper operation, and proper operation in the majority of cases will never be obtained until the councils are made to realize, through education and legislation, that they must provide competent operators and provide sufficient money for yearly repairs."

Lime in Road Work

The use of lime in road construction and maintenance will be the subject of a discussion by C. R. Stokes, manager of the Highway Department of the National Lime Association, at the eighth annual convention of that association to be held on June 8 to 11 at French Lick, Ind.

Temperature of Asphalt Pavements

The U. S. Bureau of Public Roads, during the past three years, has been conducting a series of tests to measure the internal temperatures of asphaltic pavements and to determine, in a general way, the effect of such temperature upon resistance of the pavement to displacement under traffic.

The pavements tested included different coarse-graded asphaltic concrete mixtures and sheet asphalts, laid two-inches thick on very smooth concrete foundations. Different percentages and grades of bitumen and oils were used, some of them giving pavements more susceptible to heat than any that would normally be constructed for service.

A recent report on these tests does not go into the composition of the various test sections, nor the amount of movement under traffic, except to state that some of the sections were shoved and rutted during warm weather under heavy traffic to such an extent as to be almost entirely disrupted, although the same pavements in cold weather showed no movement under equally heavy traffic. It also appeared probable that the effect of heat on the displacement of the pavement was much greater immediately after the construction of the pavement than where a pavement was completed at the beginning of cold weather and compacted by travel for several months before being subjected to high temperature.

One of the interesting features of the experiment is the much greater temperature of the asphalt wearing surface than of the air. Thermocouples of copper and constantin wire were installed in many of the pavements and connected to a central station for observation of temperatures. Most of these were set one-half inch below the surface, but in several instances additional ones were placed at one-half inch intervals down to the concrete foundation. It was found that when exposed to direct sunlight, the internal temperature of asphalt pavements is apparently always higher than that of the surrounding air. During the winter months this difference is very slight, but under summer conditions internal pavement temperatures were found 25 degrees to 35 degrees higher than the air temperatures as a common occurrence, and the difference was greater than this occasionally. A temperature of 140 degrees Fahrenheit was reached a few times.

There did not appear to be any considerable difference between the temperatures of the pavement at various depths beneath the surface, although when subjected to direct sunlight the top was always warmest. The extreme difference between top and bottom temperatures never exceeded 15 degrees, while on cloudy days they were virtually uniform throughout; and a rain, following bright, sunny conditions, frequently resulted in surface temperatures slightly lower than the bottom, owing to rapid loss of heat on the surface.

In concluding this report the writer says: "Higher temperatures aided traffic in developing instability in certain mixtures, but with lighter traffic it is certain that several of these would have been classed with those which proved satisfactory. It is clear, therefore, that pavement behavior, frequently explained on the basis of traffic only, should be analyzed also with regard to the prevailing climatic conditions at the time such traffic is imposed."

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Metering Almost Universal

More than 95 per cent. of the water departments and companies of the United States use water meters, and more than 50 per cent. meter all services. These are the figures obtained from several hundred reports made to us by water works superintendents in municipalities of all sizes and in all sections of the country, and believed to be fairly representative of the whole country. There has been opposition to metering in some sections, which must have been due to failure to appreciate its advantages, but now that Chicago, the most important stronghold of the anti-meterites, has fallen, it would appear inevitable that universal metering is to be standard practice, adopted by all cities except those that are way behind the times and perhaps a few where unusual conditions make it possible to furnish water "free as air"—to quote one of the ancient anti-meter slogans.

The growth of metering in recent years has been due not alone to education but also to changing conditions. With growth of population, water is becoming less abundant and many cities find themselves approaching the limits of their supplies and required to cut down waste. Then the necessity of purification is increasing and becoming more generally realized, and purification increases the cost of water, as does also the greater cost of coal, of labor at the pumping station, and of pipe and materials generally. In addition, house plumbing fixtures are becoming more elaborate and general and this means more use and waste of water.

Altogether, there would seem to be no possibility of any decrease in metering but every reason to believe that metering water will soon be as universal as metering gas and electricity.

Typhoid in Country Districts

The report by the U. S. Public Health Service, referred to elsewhere in this issue, that carefully conducted investigations in Alabama apparently prove that typhoid rates in that state are lower in the country districts than in any of the more thickly settled communities except the largest cities, will be of great interest to sanitarians. It has generally been believed that the reverse is true and that the highest rates are in the sparsely settled districts; and it may be that Alabama conditions are peculiar to that state.

But should this relation be found to exist the country over, this should not be taken by state health officials as an excuse for relaxing vigilance in oversight of water supplies in such districts. There still remains the danger to automobilists, summer vacationists and other occasional users of farm wells; and also the chance that typhoid germs may be brought from farms to cities in milk. For city dwellers, for years protected almost absolutely from typhoid germs, are probably more susceptible to attack by them than are country folk not so protected; there being good reasons for believing that a certain degree of immunity is acquired by habitual use from childhood up of food and drink that is more or less infectious.

"Spinning" Pipes and Linings

Casting objects of a generally tubular shape by rapidly revolving the mold, whereby centrifugal force causes the fluid material to cling to the wall of the mold while hardening, is by no means new, but has recently found new adaptations. Ten years or more ago concrete posts for supporting street wires, street signs and other purposes, were manufactured by this process. During the past three or four years there has been a development of the manufacture and use of "spun" cost-iron pipe, first by the de Lavaud method, later by the "sand spun," and quite recently by the "Mono-cast" method.

Another application of interest to water works men is the spinning of cement lining in cast iron pipes. Elsewhere in this issue will be found a brief summing up of the facts relative to the manufacture and use of this type of pipe lining. At least two large cast-iron pipe companies are prepared to furnish pipe lined by this method.

An advantage of spinning is that the material can be subjected to a greater pressure by centrifugal force than that due to its own weight or to tamping, and this pressure is more uniform and results in a product of greater and more uniform density.

There are certain details of process of manufacture and of nature of product which might be improved upon. But the advantages of this process are so unquestionable that there seems little doubt that it will be developed rapidly to a satisfactory state of art for manufacturing these and probably other products.

Financing Toledo Engineers' Salaries

Raise in salaries of engineers may require increase of revenue derived from services rendered by Engineering Division.

It seems to be generally admitted in Toledo, Ohio, that the salaries of engineers connected with the city engineering department should be increased, but the problem is presented of how to do this. In a discussion of this subject by the Commission of Publicity and Efficiency of that city, it is stated that "The present financial condition of the city makes it mandatory for any increase in expenditures to be financed by securing more money than originally estimated as the city's income for the year. The new financial laws of the state do not permit the council to raise the salary of any employe unless there is enough money collected or in the process of collection to pay for the increase."

A study has been made to learn whether an increase in the compensation to the employes of the department can be financed by increasing the earnings of the departmet itself. The accompanying table shows the receipts and expenditures of the department for 1925 and the estimated receipts and appropriation for expenditures for 1926. From this table it appears that more than half of the cost of operating the engineering department has been reimbursed from revenues received for services furnished by the department.

Receipts of Engineering Division

	1926 (Est.)	1925
Sewer Tap and Drain Permits	$10,000.00	$10,320.00
Street Opening Fees	4,500.00	5,093.10
Steam Shovel Permits	900.00	886.00
Blue Prints	80.00	83.60
Sewer Plans, Priv. Engrs.	1,700.00	1,757.10
Sewer Assessments	1,800.00	1,856.81
House Moving and Curb Cuts	3,500.00	2,501.00
Miscellaneous*	15,000.00	
Inspection Services	.....	14,929.81
Engineering Services	.....	16,682.81
	$37,480.00	$55,110.23

Expenditures of Engineering Division

	1926 (Approp.)	1925
Personal Services	$80,117.50	$84,615.04
Supplies	2,480.00	1,843.71
Transportation of Employes	560.00	439.17
Contractual	325.00	54.00
Maint. of Equipment	1,500.00	1,674.08
Outlay, new equipment	2,000.00	1,906.01
	$86,982.50	$90,532.01

*Included in the Miscellaneous Service Revenue Fund are minor receipts of the Public Service Department. Except in 1924, over 90 per cent of the receipts from this fund were for engineering and inspection services on public improvements. In 1924, about $54,000 of gasoline tax money was, by ruling of the state attorney general, placed in this fund.

A large percentage of these receipts are for inspection and engineering services in connection with public improvements which are financed through the issuance of special assessment bonds to pay the property owner's portion of the cost. It was suggested that the cost of engineering in connection with these public improvements might be included in the assessment against the property and the proceeds used in the operation of the engineering division; but the Ohio supreme court has decided that compensation for services of municipal officers, appointed for a definite period at a fixed salary required by law to be paid out of the general fund of the city, may not be included in assessments against property owners. Cleveland, Cincinnati, Canton, Akron and Zanesville are among the cities which, accepting this ruling, make no effort to assess the cost of engineering. On the other hand, Columbus, Dayton, Springfield, Youngstown, Ashtabula and probably others have adopted the following scheme for getting around this decision. They have put practically all the engineering employes working on public improvements on a per diem salary basis rather than a monthly or yearly basis, and interpret this to mean that the employe has no fixed tenure of office and no fixed salary, and that, therefore, the cost of his services in connection with that particular division of work can be assessed as a part of the cost of such work.

It is suggested, therefore, that if any readjustment is made in the salaries of the engineering employes of Toledo, as many as possible be placed on a per diem salary basis to permit assessing against property owners all services supplied by the department in connection with the usual public improvements; any employee left upon a definite salary basis spending as little time as possible upon public improvement work

It is also suggested that additional revenue for such services might be secured by increasing the charges made for sewer, tap and drain permits, street opening fees, steam shovel permits, house moving and curb cutting fees, and services performed on private jobs. Also that property owners should be charged for services in connection with constructing sidewalks, the laying out and inspecting of which is now done without charge. Also that the charges for plot approvals be increased. Real estate companys must secure approval for all plots laid out within three miles of the city limits, and it is said that the schedule of charges for this work is insufficient in many cases to pay for the services performed by the engineering department alone, while this is only one of several departments which perform services in connection with this work.

Making a Civic Survey

Early this year the city commissioners of Mason City, Iowa, passed an ordinance providing for the creation of a zoning and city plan commission for that city. This was undoubtedly the result of the making of a civic survey of that city last year by Rolland S. Wallis, municipal engineer, engineering extension department of Iowa State College; a report of which survey has been published by that department.

This civic survey "was undertaken to furnish a basis for a report intended to be of suggestive value to every municipality in Iowa."

The report should be of great interest to citizens and cities in other states than Iowa and is an admirable illustration of the kind of survey which would be of great value to any city and is a crying need for many of them.

The report first discussed the need and nature of city planning, the value of a survey and the procedure in making a survey. The survey proper is considered under the several heads, "Natural Physical Conditions," "Early History," "Population," "Area," "The Street System," "Grade Crossings," "Traffic Regulations," "Transportation," "Public Recreational Facilities," "Public Schools," "Housing," "Sanitation and Public Health," "Public Utilities," "Public and Semi-Public Buildings," "Appearance of the City," "Zoning," "Public Nuisances," "Industries" and "Carrying Out the City Plan." The report contains numerous maps and diagrams, aero photographs and detail photographs of streets, buildings, nuisances, etc.

Accompanying the report proper is a supplement containing preliminary instructions to survey committees, suggested outline for a housing survey, instructions for a street tree survey, list of survey maps prepared for Mason City, and summary of conclusions on traffic control. These, and especially the preliminary instructions, form an excellent basis for the actual carrying out of such a survey. Some indications of the thoroughness with which the several subjects are discussed may be appreciated by one or two illustrations. The matters handled by the committee on transportation are classified under the headings of railroads, aircraft, street cars, auto busses and markets, there being 23 items in all. The committee on street traffic would investigate traffic counts, traffic regulation, street accidents and sidewalk encroachments. The committee on sanitation and public health would study the subjects of sewers and sewage disposal, street cleaning, garbage disposal, rubbish disposal and public health. As an illustration of the detail of the instructions, under the head of sewerage and sewage disposal are five items as follows: "1—Indicate on a city map all the sewer mains in the streets. Show manholes as small circles, indicating the elevation in each case in feet and tenths. Between each pair of manholes indicate the size of sewer pipe in inches and the grade in per cent. Indicate sanitary sewers by continuous lines and combined sewers by dash lines. Indicate (by shading with a colored pencil) all lots served by sewers. 2—Have any sewers been cleaned? Is there any regular inspection of their condition? 3—Obtain a description of your municipal sewage treatment plant, together with figures as to the average, maximum and minimum amounts treated, degree of purification effected, etc. 4—Show the location of the sewage treatment plant on the map showing sewers. Also indicate the location of the outlet line from the plant to the point of discharge. 5—Describe such privately owned plants as may have been constructed for the separate treatment of trade sewage."

City and Country Typhoid Rates

Study of Alabama statistics shows that typhoid rates increase with decrease in population in incorporated places, but is very low in country districts.

A study has been made of typhoid fever in the state of Alabama and a discussion of some of the results of this study has been prepared by Charles N. Leach, Alabama State Board of Health, and Kenneth F. Maxcy, past assistant surgeon, U. S. Public Health Service, and published in the April 16th issue of Public Health Reports.

A part of the study was devoted to an attempt to establish the relative typhoid incidence in population units of various sizes. The units were divided into incorporated places of over 25,000 population, 10,000 to 25,000, 5,000 to 10,000, 2,500 to 5,000, 1,000 to 2,500, and 500 to 1,000, and country and unincorporated towns. In Alabama the last contains a considerable part of the population, or 1,664,868 as compared to 2,348,174 in the incorporated towns and cities.

It had been anticipated that the highest typhoid rates would be found in the smallest units of population. So far as the incorporated towns were concerned, this proved to be case, the mean of the case rates per 10,000 population for 1924 and 1925 being as follows, beginning with the largest municipalities and ending with the smallest ones: 6.3, 11.8, 16.5, 18.0, 30.7 and 44.3. The rate for the country and unincorporated towns however, instead of continuing the increasing progression, was found to drop to 5.2.

Death rates are generally more reliable than case rates since there is less probability of failure to report deaths from typhoid than typhoid cases. The death rates per 10,000, in the same order as before, were as follows: 0.9, 2.0, 2.8, 2.5, 3.5 and 5.4, with a drop to 1.3 for country and unincorporated towns.

The authors state: "While the variation of the rate inversely with the size of the town is more or less according to expectation, the finding that typhoid fever is no more prevalent among persons living in the small unincorporated communities and country districts than among persons living in the relatively well sanitated larger cities will be, to most sanitarians, a rather interesting and new conception."

To determine whether the result referred to might not be due to errors in the allocation of cases or incompleteness of the records, a special investigation was made of this point. The records were studied to learn not only the city or other localities where the patient died but also that where his home was located, in order to eliminate the error due to treating of country patients in city hospitals. Effort was also made to check up on the completeness of the returns from city and country districts. The conclusion from this supplementary study was that no such errors could be located or reasonably inferred which would materially change the figures already given.

One of the conclusions naturally reached from a study of these figures is that typhoid control measures should be directed primarily to the smaller incorporated towns, especially in sections of the country where these contain a considerable percentage of the state's population. In Alabama there are 116 towns ranging in population from 500 to 2,500 out of a total of 155 incorporated places in the state. For persons living in these towns the risk of contracting typhoid fever is at least four times as great as for residents of the larger cities. The health officials of the larger cities have apparently brought about a most commendable condition so far as the control of typhoid fever is concerned, and they may be relied upon to continue along lines already adopted. The most attention of the state authorities should therefore, it would seem, be devoted to urging and aiding the health officials of the smaller communities to reach a similar high standard of safeguarding the population against this disease.

Cement-Lined Cast-Iron Pipe

Used in Charleston, S. C., since 1922. Pipe manufacturers now apply thin lining by the "spinning" process. Specifications and prices. Experiences in different cities

This subject was discussed at a meeting of the New England Waterworks Association last December and was of such interest to the members that the information then brought out, supplemented by some subsequently obtained, was compiled by Charles W. Sherman and printed in the March issue of the *Journal* of that society. His paper, somewhat abbreviated, is as follows:

The possibility of applying cement lining to cast-iron pipe was occasionally discussed, but no serious attempt to line cast-iron pipes extensively was made, so far as the writer has been able to learn, until about the year 1922, when the centrifugal process of applying such a lining was tested. It was found that by this method it was possible to obtain a very thin but extremely smooth cement lining which would adhere to the metal of the pipe with great tenacity.

This process was applied to the "sand-spun" pipe developed by R. D. Wood & Company of Philadelphia, and at about the same time to ordinary cast-iron pipe by the American Cast Iron Pipe and Foundry Company of Birmingham.

The apparatus required is extremely simple and inexpensive. It is believed that no patents are involved. Several of the pipe companies are now prepared to apply the cement lining either to sand cast or centrifugally cast pipe.

Method of Applying Cement Lining. The method now practiced is to insert a long trough or split pipe containing a thin mixture of cement in proper quantity, and invert it within the pipe, which is then rotated at a circumferential speed of about 300 ft. per minute while the cement is spread over the interior surface by placing a pipe or roller against the cement. The rotation is then stopped and the lining examined for uniformity of spreading and additional material inserted if required. The pipe is then rotated again with a circumferential speed of about 600 ft. per minute, which has the effect of driving the solid material (cement and sand) against the wall of the pipe while the water comes to the surface. After a suitable time the rotation ceases and the pipe is rolled away and stored for curing of the cement.

Specifications. The manufacturers have adopted specifications for the cement lining of pipes and fittings, which are appended to this paper.

These specifications should be considered as tentative, and may very probably be modified if experience shall show changes to be desirable, or if the new sectional committee on cast-iron pipe of the American Engineering Standards Committee shall find changes to be advantageous. Cement lining, as well as other coatings, will come within the scope of the work of this committee.

It will be noted that the lining is made up of a cement and sand mixture in the proportion of three parts Portland cement to one part of fine sand, and that the standard thickness of the lining ranges from 1/16 in. for 4-in. and 6-in. pipe, to 3/16 in. for 20 in. and 24-in. pipes.

Prices. The present prices charged for cement lining range from about five cents per foot for 4-in. pipe to about thirty-five cents per foot for 24 in. pipe. Recent quotations from R. D. Wood & Company and the U. S. Cast Iron Pipe and Foundry Company are as follows:

Prices Quoted for Cement Lining in Cast-Iron Pipe in Cents per Linear Foot March 1926

Size of Pipe, Inches	R. D. Wood & Co.	U. S. Cast Iron Pipe & Fdry. Co.
4	5	5
6	6⅔	6⅔
8	9½	9½
10	13	13
12	17	17
16	19	19
20	25	25
24	33	35

These prices are obviously insignificant compared with the benefit to be obtained if the lining proves to be durable and provides a permanent protection against tuberculation.

Experience with Cement-Lined Cast-Iron Pipe. So far as the writer has been able to learn, the longest experience with cement-lined cast-iron pipe is that of Mr. J. E. Gibson, Manager and Engineer of the Water Department of Charleston, S. C. Copy of a report made by him in 1922, upon loss of head and carrying capacity of cast-iron pipes lined with natural cement and with Portland cement, is appended to this paper.

Experience in New England with cement-lined cast-iron pipe appears to be extremely limited. So far as the writer is aware, the earliest experience was that of Mr. Frank J. Gifford at Dedham, Mass., who laid several hundred feet of cement-lined sand-spun cast-iron pipe in 1924, and whose experience with it has been satisfactory. Mr. Gifford calls attention to the fact, however, that no lining can eliminate losses in carrying capacity which may result from accumulations of sand, if such occur in pipes carrying water from driven wells.

Mr. S. H. MacKenzie, Superintendent of Water Works at Southington, Conn., laid a few hundred feet of cement-lined cast-iron pipe in 1925. This pipe was on a dead end and during the early months of its use trouble was experienced from taste in the water. It seems probable that this could have been greatly reduced if it had been feasible to flush the pipe several times when first put in use.

The writer purchased 50 lengths of 6-in. cement-lined cast-iron pipe for the town of Belmont, Mass., which was received in December, 1925. This pipe came from Burlington, Ala., and showed no ill effects from the transportation after being teamed and unloaded without special precautions to avoid cracking the cement. The interior surface was most pleasing, and chisel cuts, made with instructions to the men to treat it roughly, failed to cause the cement to crack or to separate from the iron except for a very minute distance adjoining the cut.

The appearance of this pipe, and the promise of comparatively permanent protection to the material afforded by the cement coating, is such that this pipe has been ordered for the entire requirements of the town of Belmont for the year 1926.

Only experience extending over a long term of years will demonstrate conclusively that the coating adheres to the material so firmly that no corrosion will take place which can throw off the coating, or that chips of cement resulting from tapping may not cause trouble in meters and house services. It is possible that trouble of this kind may develop, but the writer believes that it is unlikely, and that the probable advantages outweigh the possible difficulties to such an extent that it is advisable to use pipe with cement lining wherever experience has shown that tuberculation of the pipes is a serious matter.

Specifications for Cement-Lined Cast-Iron Pipe and Fittings

Cement. The cement used for making the mortar shall be standard Portland cement, complying in all respects with the requirements of the specifications of the American Society for Testing Materials.

Sand. Sand used for the mortar shall be clean, free from organic matter, loam, and other foreign material. It shall be screened, before mixing with the cement, through a screen having a mesh of not coarser than 12 to 1 inch.

Proportion. The mortar used for lining the pipe shall be mixed in approximately the proportions of one part of screened sand to three parts Portland cement by volume. Cement mortar shall be thoroughly mixed, preferably in a power mixer, only sufficient water being added to it to permit of depositing and properly distributing it in the pipes to be coated. The mortar, after mixing, shall be used promptly for lining the pipe, and no mortar that has attained its initial set shall be used.

Preparation of Pipe for Lining. The pipe shall not be coated on the inside with tar or any asphaltum product, but the interior surface shall be thoroughly cleaned of core sand, mud, grease, or other foreign matter, leaving a clean iron surface on which the cement lining is to be applied. Before lining, the pipe shall be hydrostatically tested.

Method of Applying Lining. The lining shall be applied to the interior surface of the cast-iron pipe centrifugally. The mortar shall be spread evenly over the inner surface of the pipe by mechanical means while the pipe is being revolved at a peripheral speed of about 300 ft. per minute. The pipe shall then be allowed to come to rest and a careful examination made for uniformity of lining. Any bare spots may be covered with mortar. The pipe shall then be immediately revolved at a peripheral speed of 600 ft. per minute for a sufficient length of time to obtain a smooth interior surface, due care being taken to avoid the separation of the ingredients. The bottom of the bell and the end of the spigot may be covered with mortar by applying with a brush. All mortar shall be removed from the interior surface of the bell, except as above noted.

Outside Coating. If desired, the pipe may be coated outside with tar or asphaltum brushed or sprayed on.

Lining Fittings. The interior surface of the fittings shall be lined by applying the cement mortar with a brush, uni-

formly and evenly, after which the fitting is to be jarred by rapping it with a hammer until a smooth surface of the lining is secured.

Thickness of Lining. The standard average thickness of lining for various sizes shall be as follows:

Nominal Size of Pipe	Thickness of Cement Lining
4-inch	1/16 of an inch
6-inch	1/16 " " "
8-inch	1/8 " " "
10-inch	1/8 " " "
12-inch	1/8 " " "
16-inch	1/8 " " "
18-inch	3/16 " " "
20-inch	3/16 " " "
24-inch	3/16 " " "

A tolerance of 1/32 in. in thickness of lining shall be permitted on 4-in. and 6-in. pipe and a tolerance of 1/16 in. on sizes from 8-in. to 24-in.

Thicknesses other than standard can be furnished if desired.

Curing Cement Lining. The cement-lined pipe shall be immediately protected in a suitable manner from the direct rays of the sun. To prevent too rapid drying, suitable means shall be provided to keep lining damp for a period of at least 24 hours. During this period when lining is sufficiently set, it shall be thoroughly wet down. In cold weather, proper precaution shall be taken to prevent freezing.

No pipe shall be shipped until the lining is thoroughly hard, and in no case shall shipment be made in less than 48 hours.

REPORT ON EXPERIENCES IN CHARLESTON

In the report by J. E. Gibson, referred to by Mr. Sherman, he reviews the early experience of Charleston, S. C. (see PUBLIC WORKS for November, 1923) and states that the city in 1924 tested the carrying capacity of cement lining centrifugally placed, with the results given in the following table:

Test of 6-in. Cement-Lined Cast-Iron Pipe, Portland Cement Lining, Centrifugally Placed.

Thickness of lining 1/16 in. Net internal diameter 5⅞ in. Section tested 250 ft. Water measured by standard disc type meter. Carbon tetrachloride and mercury manometer used to measure friction loss. Tested August, 1924.

Flow in 1000 Gal. per 24 Hours.	Velocity in Ft. per Second	Loss of Head per 100 Ft.	Value of "C" in Hazen's and William Formula.
149.8	1.23	1.34	124.8
180	1.45	1.72	131.1
299.5	2.46	3.79	142.5
407.4	3.35	6.56	143.8
498	4.09	9.23	146.2
597	4.91	13.11	145.3
683	5.61	16.8	145.3
		Average	137
		Average last five tests	144.5

In the above table the two first lines represent results using carbon tetrachloride of 1½ specific gravity, and the fluctuations in the columns were so great as to make it difficult to read satisfactorily. Therefore, we feel that these results are not nearly so representative or dependable as the tests indicated by the last five where mercury manometer was used, and the oscillations of the column were reduced to a negligible quantity.

In the foregoing test all apparatus was calibrated and piezometric pipe was used to connect the ends of the sections of pipe under test so that all readings were made at one point and simultaneously. All tests are figured upon the actual net internal diameter of the pipe, and each test reported represents the algebraic average of one-half minute observations for five and ten minute periods.

Our experience, covering a period of about three years, shows that the pipe is not incrustating or tuberculating, the carrying capacity is being maintained, and no difficulty is being experienced in tapping or cutting the pipe. A number of Smith taps have been made where the section cut out by the cutter permits of examination, showing that the cement-lining is tenaciously adhering to the cast iron without tuberculating or rusting underneath the coating.

The Department now has in service ten miles of cement-lined cast-iron mains from 4 in. to 24 in. in diameter.

Sanitary Engineering in Maryland in 1925

Reducing nuisance and stream pollution by garbage reduction works. Decolorizing swampy water. Sewage aeration and sludge digestion

In his report for the year 1925, Abel Wollman, chief engineer of the Bureau of Sanitary Engineering of Maryland, describes the advance being made in sanitary conditions throughout the state, especially those related to water supply, sewerage and stream pollution. The progress made was to a considerable extent facilitated by the existence of the Metropolitan Districts of the state. (See PUBLIC WORKS for August, 1924.)

GARBAGE REDUCTION WORKS

Among the stream pollution cases receiving the attention of the bureau, one of the most important was that connected with the Sanitary Reduction Company's garbage works at Bodkin Point, where the garbage from the city of Baltimore is treated. Here, both water pollution and aerial nuisance existed. The company's chemical engineer conducted a number of experiments to develop an effective method of treating the liquid wastes from the grease separators. It was found that plain sedimentation with 24 hours subsidence would remove a large amount of the solids and grease formerly discharged into the creek. As a result of this experimental work, two new 60,000-gallon tanks were installed for removing the settleable solids and grease. These tanks operate on the fill and draw basis and the company's engineer states that they remove daily an average of 4 tons of dry material and 2 barrels of grease. Tests based upon representative 24-hour composite samples showed that these tanks reduced the total solids from 117,105 p.p.m. to 3,832 or 96.7 per cent.; reduced the suspended solids from 22,500 to 860 or 96.2 per cent.; and reduced the grease from 12,622 to 3,212 or 74.5 per cent.

A second source or stream pollution at this plant is the waste removed by the scrubbers which wash the dryer gases. After using two small settling tanks in parallel to treat this waste, a new concrete basin was built and put in series with these tanks. This treatment effects about one hour subsidence and materially reduces the suspended solids discharged into the scrubber liquor.

Considerable odor at this plant was due primarily to the gases from the tankage driers. A specially designed scrubber was installed, so constructed as to contain layers of excelsior through which all the dryer gases must pass and since then little smoke or

odor escapes from the smokestack. In addition to this treatment, the gases are dosed with from 14 to 18 pounds of liquid chlorine per day.

DECOLORIZING WATER

In 1924 the Wicomico river had been tentatively selected as the source for a new water supply for the city of Salisbury. As this stream runs through a swampy area it is highly colored and the bureau, last year, conducted experiments on decolorizing it. Various combinations of alum, sedimentation and filtration were tried and it was found that an original color of 50 p.p.m. could be reduced to between 17 and 18 p.p.m. by the use of one-half of a grain of alum per gallon of water. It was found that a greater amount than one-half grain did not produce sufficient additional improvement to warrant its use.

SEWAGE AERATION

Two of the more important sewage studies made during the year were those at the Hagerstown sewage treatment works and sludge digestion experiments at institutional treatment plants. The Hagerstown sewerage commission was proposing to instal a Peck aerator at its sewage treatment plant and the bureau conducted investigations to determine the degree of purification of this sewage required to prevent the creation of a nuisance when it is discharged into Antietam Creek; also to determine the cost of this aerator as compared with other aerating devices. The first study was made on sewage which had been screened and passed through a grit chamber direct to the aeration tank, then through a settling tank equipped with a Dorr thickener, and thence to Antietam Creek. During this test the air from the Peck aerator was augmented by some compressed air which entered the tanks through perforated pipes near the center influent well.

During the second study, the sewage was screened, settled in one of the Dorr clarifiers, then aerated, resettled in a second clarifier and discharged into the creek; compressed air being forced continuously into the tank through filtros disks in addition to that supplied by the Peck aerator. As a result of these studies it may be stated that the Peck aerator seems to be mechanically efficient and produces good inspiration and distribution of air, but does not supply a sufficient amount of air for proper oxidation of this sewage. The results obtained during the second test were considerably better than those secured at the time of the first investigation, especially with respect to the oxygen content of the final effluent. The bureau did not feel warranted, as a result of these tests, in approving the activated sludge unit as installed for this sewage, but expected to continue its study during the year 1926.

STIMULATING SLUDGE DIGESTION

Of the several institutional sewage treatment works in the state, only one was found to be producing a good sludge by natural means that at the Crownsville state hospital. At all the others, the bacterial action was retarded, resulting in a production of only partially digested sludge. In order to learn, if possible, some means of seeding these tanks other than by using previously digested sludge (which would have to be transported in rather large volumes from other plants), several experiments were tried to determine a substitute for this. Lime applied to the scum in gas vents followed by churning, did not result satisfactorily. The tank in one plant was seded with secondary Imhoff tank sludge, while at another the superintendent was requested to seed the Imhoff tank with cow manure, and at a third to seed a primary Imhoff tank with the contents of an old privy. It is hoped to obtain some helpful data from these studies.

Water Works Statistics for 1925

Reports from nearly four hundred cities of all sizes and geographical districts tell amounts of mains laid of different materials and sizes. Percentage of services metered and features of meter rates in the different cities. Chemical used in purifying water.

In obtaining by questionnaire and tabulating information concerning amount of water mains laid by different cities in 1925, as has been our practice for many years, we have classified the cast-iron mains into those less than 6 inches diameter; those from 6 to 12 inches diameter; and those larger than 12 inches. Steel mains are classified as 12 inches or smaller, and larger than 12 inches. Most of the pipes of other materials (it was specified that only those laid as street mains be included—no services) were 2 inches diameter or smaller, probably in most cases laid with a view to replacing them later with larger pipe.

The information concerning metering and meter rates is very interesting and is discussed in another part of this issue. The questions asked were: "What percentage of your services are metered?" "What is your maximum meter rate?" "This applies up to what consumption?" "What is your minimum meter rate?" "This applies beyond what consumption?" "What is the average meter rate received? (Total receipts from meters divided by total amount sold by meter)."

Concerning Purification, we asked: "Do you treat your water with hypochlorite? With liquid chlorine? With iron sulphate? With copper sulphate? With alum? With what other chemicals?"

Inquiries as to the kind of chemicals used in purifying water were replied to by about 200 of the first 300 cities replying. Most of these, or a total of 171, used liquid chlorine, while 15 used hypochlorite, both being used in each of two cases. Alum was used by 89 cities and iron sulphate by 11. Lime was used by 31 cities and soda ash by 12. Copper sulphate was reported by 38 cities, presumably in each case for destruction of algae. One city reported the use of Permutit.

Water Mains Laid in 1925

City	Municipal (M) or Private (P)	Cast Iron Pipe: Under 6" Feet	Cast Iron Pipe: 6", 8", 10" & 12" Feet	Cast Iron Pipe: Larger than 12" Feet	Steel Pipe: 12" and smaller Feet	Steel Pipe: Larger than 12" Feet	Other Kinds of Pipe: Kind	Other Kinds of Pipe: Size Inches	Other Kinds of Pipe: Length Feet
Alabama:									
Florala	M	.....	500	.....	.....	.....	Galvanized	1½	600
Gadsden	M	.....	2,000	.....	.....	.....	Galvanized	1½	3,000
Arkansas:									
Mena	M	300	200	.....	.....	.....	.....	...	.....
Nashville	M	400	.....	.....	250	.....	.....	...	.....
West Helena	P	.....	.....	.....	.....	.....	Galvanized	2"	600
Colorado:									
Colorado Springs	M	1,392	10,101	.....	.....	190	.....	...	.....
Montrose	M	1,600	.....	.....	3,400	.....	.....	...	.....
Connecticut:									
Bridgeport	P	.....	38,000	.....	.....	.....	.....	...	.....
Danielson	P	.....	2,000	.....	.....	.....	.....	...	.....
Darien	P	.....	1,980	.....	.....	.....	.....	...	.....
Putnam	M	900	.....	.....	.....	.....	.....	...	.....
So. Manchester	P	4,500	.....	.....	.....	.....	.....	...	.....
Westport	P	4,440	6,138	15,507	.....	.....	.....	...	.....
Willimantic	M	.....	450	.....	.....	.....	.....	...	.....
Florida:									
Lakeland	M	.....	90,000	.....	.....	.....	Galvanized	2"	40,000
Georgia:									
Cedartown	M	3,000	.....	.....	.....	.....	.....	...	.....
La Grange	M	.....	17,000	.....	.....	.....	.....	...	.....
Thomasville	M	.....	1,000	.....	.....	.....	.....	...	.....
Illinois:									
Hillsboro	M	5,280	26,400	.....	.....	.....	.....	...	.....
Lake Forest	M	.....	16,000	8,600	.....	.....	.....	...	.....
Mattoon	M	.....	9,000	.....	.....	.....	.....	...	.....
Naperville	M	6,596	4,115	.....	.....	.....	.....	...	.....
Oak Park	M	1,310	31,762	.....	.....	.....	.....	...	.....
Olney	M	.....	.....	.....	.....	.....	.....	...	.....
Quincy	M	1,013	15,728	.....	.....	.....	Galvanized	2	300
Rock Island	M	.....	9,040	.....	.....	.....	.....	...	.....
Springfield	M	1,226	20,134	.....	.....	.....	.....	...	.....
Indiana:									
Batesville	P	1,865	.....	.....	.....	.....	.....	...	.....
Columbia City	M	1,332	.....	.....	561	.....	.....	...	.....
Connersville	M	900	4,330	755	.....	.....	.....	...	.....
Elkhart	M	672	3,660	.....	.....	.....	.....	...	.....
Greenfield	M	2,000	.....	.....	.....	.....	.....	...	.....
Jasper	M	.....	600	.....	1,200	.....	.....	...	.....
Lebanon	M	.....	3,000	.....	.....	.....	.....	...	.....
Muncie	M	.....	3,300	.....	16,000	.....	.....	...	.....
Nappanee	P	.....	.....	.....	.....	.....	.....	...	.....
Newcastle	..	4,000	8,300	300	.....	.....	Galvanized	2"	600
Rensselaer	M	2,000	.....	.....	.....	.....	.....	...	.....
Richmond	P	.....	17,223	.....	.....	.....	.....	...	.....
Rushville	M	.....	10,760	.....	.....	.....	.....	...	.....
Seymour	..	350	.....	.....	.....	.....	.....	...	.....
Shelbyville	P	.....	1,000	.....	.....	.....	.....	...	.....
Iowa:									
Albia	M	5,200	600	.....	.....	.....	.....	...	.....
Boone	M	695	10,187	.....	.....	.....	.....	...	.....
Burlington	P	7,522	3,395	.....	.....	.....	.....	...	.....
Cedar Rapids	M	1,888	18,475	.....	.....	.....	.....	...	.....
Charles City	M	2,862	2,367	.....	.....	.....	.....	...	.....
Dubuque	M	502	18,148	.....	.....	.....	.....	...	.....
Ft. Dodge	M	1,090	10,989	.....	.....	.....	.....	...	.....
Independence	M	6,000	.....	.....	.....	.....	.....	...	.....
Indianola	M	5,280	.....	.....	.....	.....	.....	...	.....
Marshalltown	M	.....	2,585	.....	.....	.....	.....	...	.....
Mason City	M	1,320	5,280	.....	.....	.....	.....	...	.....
Muscatine	M	3,000	2,000	.....	.....	.....	.....	...	.....
Sioux City	M	142	40,081	8,258	.....	.....	.....	2"	300
Vinton	..	1,712	.....	.....	2,200	.....	Galvanized	2"	41,188
Kansas:									
Abilene	M	2,000	.....	.....	.....	.....	.....	...	.....
Coffeyville	M	3,500	700	.....	.....	.....	.....	...	.....
Emporia	M	3,000	1,500	.....	.....	.....	.....	...	.....
Garden City	..	744	1,956	.....	.....	.....	.....	...	.....
Humboldt	M	.....	.....	.....	.....	.....	.....	...	.....
Hutchinson	P	.....	4,541	.....	.....	.....	.....	1¼, 1½ & 2	1,700
Junction City	..	1,100	.....	.....	.....	.....	.....	...	.....
Mulberry	..	.....	.....	.....	.....	.....	.....	...	.....
Newton	M	3,040	.....	.....	.....	.....	Galvanized	2"	500
Ottawa	M	.....	15,840	.....	645	.....	.....	...	.....
Paola	M	.....	.....	.....	1,000	.....	.....	...	.....
Kentucky:									
Ashland	M	10,580	34,707	.....	.....	.....	Wrought Iron	...	8,179
Glasgow	P	1,600	14,520	.....	.....	.....	.....	...	.....
Hopkinsville	P	1,772	1,084	.....	.....	.....	Galvanized	Less than 4"	282
Lexington	P	14,047	15,410	.....	.....	.....	Pre-caulked c.i.	1½ & 2	4,800
Louisville	M	378	104,704	9,926	.....	.....	.....	...	.....
Maysville	P	3,000	6,500	.....	.....	.....	.....	...	.....
Middlesboro	P	3,500	500	.....	.....	.....	.....	...	.....
Paris	P	.....	700	.....	.....	.....	.....	...	.....
Louisiana:									
Rayne	..	.....	.....	.....	1,500	.....	.....	...	.....
Maine:									
Calais	P	.....	.....	.....	.....	.....	.....	2"	1,000
Caribou	P	1,320	.....	.....	200	.....	.....	...	.....
Kittery	..	160	.....	.....	.....	.....	.....	2"	400
Livermore Falls	M	550	800	.....	600	.....	.....	...	.....
Pittsfield	M	1,800	500	.....	.....	.....	.....	1¼	300
Rockland	P	300	880	.....	.....	.....	.....	...	.....
Skowhegan	P	895	.....	.....	.....	.....	.....	...	.....
Maryland:									
Baltimore	M	.....	401,280	79,200	.....	.....	.....	...	.....
Hagerstown	M	.....	2,000	.....	.....	.....	.....	...	.....

City	Municipal (M) or Private (P)	Cast Iron Pipe: Under 6" Feet	Cast Iron Pipe: 6", 8", 10" & 12" Feet	Cast Iron Pipe: Larger than 12" Feet	Steel Pipe: 12" and smaller Feet	Steel Pipe: Larger than 12" Feet	Other Kinds of Pipe: Kind	Other Kinds of Pipe: Size Inches	Other Kinds of Pipe: Length Feet
Massachusetts:									
Adams	M	493	4,462	.....	.....	.....	.....	...	.....
Brockton	M	.....	6,321	.....	.....	.....	.....	...	.....
Dalton	M	500	.....	.....	.....	.....	.....	...	.....
Danvers	M	.....	2,918	.....	.....	.....	.....	...	.....
East Bridgewater	M	800	11,000	.....	.....	.....	.....	...	.....
Falmouth	..	1,082	14,395	.....	.....	.....	.....	...	.....
Fitchburg	M	.....	3,500	2,200	.....	.....	Wrought Iron	2"	5,000
Melrose	M	.....	8,600	.....	.....	.....	.....	...	.....
Northampton	M	.....	15,000	.....	.....	.....	.....	...	.....
North Andover	M	.....	825	.....	.....	.....	.....	...	.....
North Attleboro	M	.....	42,240	.....	.....	.....	.....	...	.....
Salisbury	P	.....	.....	.....	300	.....	Wrought Iron	...	2,000
So. Hadley Falls	M	.....	350	.....	.....	.....	.....	...	.....
Spencer	M	.....	1,080	.....	.....	.....	Mc Wane	2"	240
Swampscott	..	.....	4,416	.....	.....	.....	.....	...	.....
Taunton	M	.....	1,015	.....	.....	.....	.....	...	.....
Winthrop	M	165	893	.....	.....	.....	.....	...	.....
Michigan:				.....	.....	.....			
Ann Arbor	M	.....	31,317	.....	.....	.....	.....	...	.....
Benton Harbor	M	10,560	10,560	.....	.....	.....	.....	...	.....
Detroit	M	497	841,508	44,952	.....	497	.....	...	.....
Dowagiac	M	.....	2,640	.....	.....	.....	Byers pipe	2"	500
Houghton	M	.....	100	.....	200	.....	.....	...	.....
Jackson	M	.....	26,822	.....	.....	.....	.....	...	.....
Ludington	M	.....	5,280	.....	.....	.....	.....	...	.....
Marshall	M	800	1,200	.....	.....	.....	.....	...	.....
Mt. Clemens	M	19,377	400	200	.....	.....	.....	...	.....
Negaunee	..	8,329	6,012	.....	.....	.....	.....	...	.....
Otsego	M	2,400	.....	.....	.....	.....	.....	...	.....
Rochester	M	1,095	740	.....	.....	.....	.....	...	.....
Traverse City	M	.....	4,000	.....	.....	.....	.....	...	.....
Minnesota:									
Anoka	M	2,000	.....	.....	.....	.....	.....	...	.....
Crookston	P	2,500	.....	.....	.....	.....	.....	...	.....
Minneapolis	M	107,648	.....	5,292	.....	8,393	.....	...	.....
Rochester	M	862	3,411	.....	.....	.....	.....	...	.....
Stillwater	M	.....	853	.....	.....	.....	.....	...	.....
West Minneapolis	M	300	1,899	.....	.....	.....	.....	...	.....
Mississippi:									
Canton	M	300	500	.....	.....	.....	.....	...	.....
Jackson	M	.....	6,000	4,000	.....	.....		2"	8,000
Vicksburg	M	.....	15,840	.....	.....	.....	.....	...	.....
Missouri:									
Columbia	M	15,840	5,280	.....	.....	.....	.....	...	.....
Liberty	M	2,000	.....	.....	.....	.....	.....	...	.....
St. Charles	M	.....	.....	.....	.....	1,319	.....	...	.....
Montana:									
Billings	M	484	10,613	.....	.....	.....	.....	...	.....
Kalispell	M	2,840	46,750	3,700	.....	.....	.....	...	.....
Missoula	P	.....	.....	320	2,000	4,500	.....	...	.....
Nebraska:									
Fremont	M	550	.....	.....	.....	.....	.....	...	.....
Hastings	M	5,325	600	.....	.....	.....	.....	...	.....
Havelock	M	1,300	.....	.....	.....	.....	.....	...	.....
Holdrege	M	4,600	780	.....	.....	.....	.....	...	.....
Lincoln	M	15,562	18,552	.....	.....	.....	.....	...	.....
Superior	M	.....	1,000	.....	.....	.....	.....	...	.....
New Hampshire:									
Claremont	M	.....	6,206	.....	.....	.....	.....	...	.....
Lebanon	M	.....	1,000	.....	.....	.....	.....	...	.....
New Jersey:									
Belleville	M	.....	12,003	.....	.....	.....	.....	...	.....
Dover	M	1,000	500	.....	.....	.....	.....	...	.....
Hackensack Water Co., (47 municipalities)	P	.....	183,000	.....	.....	.....	.....	...	.....
Hawthorne	M	79,200	.....	.....	.....	.....	.....	...	.....
Madison	M	7,000	4,500	.....	.....	.....	.....	...	.....
Montclair	M	.....	8,533	.....	.....	.....	.....	...	.....
Newton	M	900	.....	.....	.....	.....	.....	...	.....
Nutley	M	100	24,400	.....	.....	.....	.....	...	.....
Red Bank	M	5,900	.....	.....	.....	.....	.....	...	.....
New York:									
Auburn	..	.....	3,000	.....	.....	.....	.....	...	.....
Binghamton	M	.....	9,500	.....	.....	.....	.....	...	.....
Catskill	M	3,500	.....	.....	.....	.....	.....	...	.....
Clyde	P	.....	.....	.....	.....	.....	.....	1½ & 2	2,600
Dansville	M	500	.....	.....	.....	.....	Wrought pipe	2	200
Elmira	M	.....	19,939	.....	.....	.....	Wrought iron galv.	1½ & 2	2,863
Fairport	M	3,000	.....	.....	.....	.....	.....	...	.....
Fort Plain	M	600	.....	.....	.....	.....	.....	...	.....
Geneva	M	62,000	.....	.....	.....	.....	.....	...	.....
Jamestown	M	18,000	26,000	.....	.....	.....	.....	...	.....
Middletown	M	586	1,208	.....	.....	.....	.....	...	.....
Olean	M	3,000	5,000	.....	.....	.....	.....	...	.....
Ossining	M	.....	700	.....	.....	.....	.....	...	.....
Oswego	M	.....	1,500	.....	.....	.....	Galvanized	3"	2,800
Port Jervis	P	365	.....	.....	.....	.....	.....	...	.....
Rensselaer	P	600	2,000	.....	.....	.....	.....	...	.....
St. Johnsville	M	200	42,240	.....	.....	.....	.....	...	.....
Scarsdale	M	.....	22,440	600	.....	.....	.....	...	.....
Seneca Falls	P	.....	215	.....	423	.....	.....	...	.....
Syracuse	M	33	23,700	2,138	.....	.....	.....	...	.....
Tarrytown	M	.....	2,500	.....	.....	.....	.....	...	.....
Waterford	M	.....	1,976	.....	.....	.....	.....	...	.....
North Carolina:									
Greensboro	M	.....	88,859	.....	.....	.....	.....	...	.....
High Point	M	.....	10,000	22,800	.....	.....	.....	...	.....
Kinston	M	.....	1,100	.....	.....	.....	.....	...	.....
Mooresville	M	2,000	3,000	.....	.....	.....	.....	...	.....
Raleigh	M	.....	52,229	.....	.....	.....	.....	...	.....
Rocky Mount	M	.....	4,700	.....	3,000	.....	.....	...	.....

	Municipal (M) or Private (P)	Cast Iron Pipe			Steel Pipe		Other Kinds of Pipe		
		Under 6" Feet	6", 8", 10" & 12" Feet	Larger than 12" Feet	12" and smaller Feet	Larger than 12" Feet	Kind	Size Inches	Length Feet
North Dakota.									
Fargo	M	.....	12,963	4,118	.....	.....	.....	...	.....
Ohio:									
Akron	M	528	85,536	.....	.....	.....	.....	...	.....
Canton	M	1,581	37,345	.....	.....	.....	Wrought iron	1" to 2"	24,257
Chillicothe	P	2,800	2,200	.....	.....	.....	.....	...	.....
Cincinnati	M	4,189	77,121	16,026	.....	.....	.....	...	.....
Columbus	M	1,581	83,661	15,320	46,310	.....	.....	...	.....
East Liverpool	M	1,000	.....	.....	.....	.....	.....	...	.....
Eaton	M	.....	.....	.....	.....	.....	McWane precaulked	2"	500
Fostoria	M	.....	6,600	.....	.....	.....	.....	...	.....
Kent	M	.....	1,500	.....	.....	.....	.....	...	.....
Lakewood	M	.....	6,100	.....	.....	.....	.....	...	.....
Medina	M	550	200	.....	.....	.....	.....	...	.....
Middletown	M	.....	7,150	.....	.....	.....	.....	...	.....
Milan	M	1,924	4,800	.....	.....	.....	.....	...	.....
Montpelier	M	.....	.....	.....	500	.....	.....	...	.....
Navarre	M	.....	.....	.....	.....	.....	.....	4	300
Niles	M	.....	3,000	4,000	.....	.....	.....	...	.....
Portsmouth	M	.....	10,800	.....	.....	.....	.....	...	.....
Ravenna	..	2,400	220	.....	.....	.....	.....	...	.....
Shelby	P	.....	4,000	.....	.....	.....	.....	...	.....
Struthers	P	655	26,514	2,000	.....	.....	.....	...	.....
Warren	M	.....	36,646	561	.....	.....	.....	...	.....
Wilmington	P	3,000	2,000	.....	.....	.....	.....	...	.....
Oklahoma:									
Guthrie	M	.....	.....	.....	200,000	.....	.....	...	.....
Pennsylvania:									
Beaver	M	3,500	.....	.....	.....	.....	.....	...	.....
Bradford	M	.....	2,200	.....	.....	.....	Galvanized	2	1,800
Chester	P	1,865	11,205	53	.....	.....	.....	...	.....
Clearfield	P	3,320	938	.....	.....	.....	Galvanized	2"	30
Connellsville	..	.....	5,300	.....	2,000	.....	.....	...	.....
Duquesne	M	.....	6,000	6,300	.....	.....	.....	...	.....
Hanover	P	400	4,600	.....	.....	.....	.....	...	.....
Huntington	M	1,200	.....	.....	.....	.....	.....	...	.....
Jersey Shore	P	2,500	.....	.....	.....	.....	.....	...	.....
Midland	P	.....	.....	.....	975	.....	.....	...	.....
Reading	M	.....	20,009	4,685	.....	.....	.....	...	.....
Schuylkill-Haven	M	2,500	.....	.....	.....	.....	.....	...	.....
Shamokin	..	.....	15,278	5,071	.....	.....	.....	...	.....
Sharpsville	M	21,120	.....	.....	.....	.....	.....	...	.....
Susquehanna	P	.....	650	.....	.....	.....	.....	...	.....
Rhode Island:									
Bristol and Warren	P	.....	.....	1,004	1,728	.....	.....	...	.....
South Carolina:									
Anderson	P	.....	440	.....	.....	.....	.....	...	.....
Batesburg	P	1,000	.....	.....	.....	.....	Galvanized	2	1,000
Cheraw	M	.....	500	.....	2,000	.....	.....	1¼, 1½	.....
Easley	M	.....	13,000	.....	.....	.....	Wrought Iron	... & 2	 2,000
South Dakota:									
Mitchell	..	68,738	3,537	.....	.....	.....	.....	...	.....
Watertown	M	.....	1,725	.....	.....	.....	.....	...	.....
Tennessee:									
Elizabethton	P	2,500	.....	.....	.....	.....	.....	1, 1½ & 2	13,000
Ennis	M	2,000	1,000	.....	.....	.....	.....	...	.....
Maryville	..	2,000	.....	.....	.....	.....	.....	...	.....
Memphis	M	.....	87,342	.....	.....	.....	.....	...	.....
Texas:									
Bay City	M	.....	5,000	.....	.....	.....	.....	...	.....
El Paso	M	2,000	20,015	.....	10,000	.....	.....	...	.....
Hillsboro	M	4,000	3,400	.....	.....	.....	.....	...	.....
Longview	M	.....	3,400	.....	.....	.....	.....	...	.....
Mart	M	.....	21,000	.....	.....	.....	.....	...	.....
Mexia	M	.....	33,000	.....	.....	.....	.....	...	.....
Yoakum	P	.....	3,000	.....	.....	.....	.....	...	.....
Utah:									
Tooele	M	3,000	.....	.....	.....	.....	Galvanized	2"	300
Vermont:									
Barton	M	300	400	.....	.....	.....	.....	...	.....
Bennington	M	.....	5,280	.....	.....	.....	.....	...	.....
Newport	M	6,500	700	.....	.....	.....	.....	1¼ & 2	600
Virginia:									
Charlottesville	M	.....	1,100	.....	.....	.....	.....	...	.....
Lynchburg	M	1,689	.....	.....	.....	.....	.....	...	.....
Richmond	M	10,281	49,171	.....	.....	.....	.....	...	.....
Washington:									
Aberdeen	M	4,000	8,500	.....	10,000	.....	Wood	6	7,920
Bellingham	M	3,000	35,000	25,000	.....	.....	.....	...	.....
Centralia	M	.....	.....	.....	1,000	.....	Wood	4 & 6	7,000
Dayton	M	.....	.....	.....	.....	.....	Matheson	10	300
Olympia	M	.....	2,500	.....	.....	.....	Wood creosoted	...	4,000
Pullman	M	1,600	3,000	.....	.....	.....	.....	...	.....
Raymond	M	200	2,400	1,500	.....	.....	Concrete pipe	18	1,600
South Bend	P	.....	.....	.....	.....	.....	Wrought iron	4, 6 & 8	1,580
Walla Walla	M	.....	.....	.....	800	1,200	.....	...	.....
Winlock	P	1,800	.....	.....	.....	.....	.....	...	.....
West Virginia:									
Charleston	P	16,209	4,100	.....	.....	.....	.....	...	.....
Follansbee	P	200	.....	.....	.....	.....	.....	...	.....
Salem	M	4,000	.....	.....	.....	.....	.....	...	.....
Welch	P	2,000	2,500	.....	.....	.....	.....	...	.....
Weston	P	.....	400	.....	.....	.....	.....	...	.....
Wisconsin:									
Antigo	..	1,000	6,000	.....	.....	.....	.....	...	.....
Appleton	M	514	7,972	.....	.....	.....	.....	...	.....

City	Municipal (M) or Private (P)	Cast Iron Pipe: Under 6" Feet	Cast Iron Pipe: 6", 8", 10" & 12" Feet	Cast Iron Pipe: Larger than 12" Feet	Steel Pipe: 12" and smaller Feet	Steel Pipe: Larger than 12" Feet	Other Kinds of Pipe: Kind	Other Kinds of Pipe: Size Inches	Other Kinds of Pipe: Length Feet
Wisconsin (Continued)									
Chippewa Falls	M	175	1,015	.....	.....	.....	.....	...	.....
Cudahy	M & P	.....	3,500	.....	.....	.....	.....	...	.....
Fond du Lac	M	5,732	9,246	.....	.....	.....	Galvanized	1"	3,365
Janesville	M	487	14,639	145	.....	.....	Extra heavy lead	1¼	1,350
Jefferson	M	775	344	.....	.....	.....	.....	...	.....
Ladysmith	M	780	1,074	.....	.....	.....	.....	...	.....
Lancaster	M	1,100	.....	.....	.....	.....	.....	...	.....
Madison	M	1,178	19,694	7,970	.....	.....	.....	...	.....
Manitowoc	M	.....	10,560	.....	.....	.....	.....	...	.....
Milwaukee	M	.....	170,406	23,535	.....	.....	.....	...	.....
Neenah	M	150	3,000	.....	.....	.....	Lead service main	1½, 1¼, 2	1,030
Shawano	M	4,000	500	.....	.....	.....	.....	...	.....
So. Milwaukee	M	.....	11,544	.....	.....	.....	.....	...	.....
Watertown	M	.....	4,218	.....	.....	.....	.....	...	.....

Meter Rates

Percentages of services metered, maximum and minimum rates charged, and the average rate of payment received for metered water, in more than three hundred cities.

City	Percentage of Services Metered	Maximum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate: For Consumption Less than	Minimum Rate: Cents per 100 cu ft. (c) or 1,000 gal. (g)	Minimum Rate: For Consumption More than	Average Rate of all metered Water—Cents
Alabama:						
Florala	60	25 g	5,000 per mo.	20 g	5,000 per mo.	($2.12a)
Gadsden	100	37½ c	200 per mo.	25 c	5,000 per mo.	.....
Arkansas:						
Benton	100	40 g	3,000 per mo.	10 g	200,000 per mo.	($2.50a)
Malvern	66	40 g	25,000 per mo. b.	.....	.....	.....
Mena	100	50 g	2,000 per mo.	30 g	2,000 per mo.	.....
Nashville	100	50 g	3,500 per mo.	17.5 g	50,000 per mo.	.....
Rogers	75	50 g	2,000 per mo.	10 g	400,000 per mo.	($1.50a)
Searcy	100	40 g	.....	20 g	20,000 per mo.	35
West Helena	33⅓	60 g	2,500 per mo.	10 g	300,000 per mo.	24
Colorado:						
Colorado Springs	3	15 g	.....	8 g	.....	.....
Montrose	20	30 g	10,000 per mo.	10 g	200,000 per mo.	.....
Sterling	100	35 g	4,000 per mo.	.....	.....	.....
Connecticut:						
Bridgeport	20	13½ c	7,000 per quarter	6 c	40,000 per quarter	7
Danielson	5	33⅓ g	72,000 per quarter	13⅓ g	20,000 per day	.....
Darien	100	40 c	5,000 per quarter	30 c	10,000 per quarter	36.1
Putnam	5	25 g	1,000 per day	12½ g	20,000 per day	17½
So. Manchester	100	25 c	10,000 per quarter	10 c	100,000 per quarter	27.3d
Westport	93	15 cp	66,000 per quarter	13½ cp	66,000 per quarter	18
Willimantic	90	35 g	.....	9 g	.....	.....
Florida:						
Lakeland	100	33⅓ g	3,000 per mo.	12 g	100,000 per mo.	23
Georgia:						
Americus	100	23½ g	12,750 per quarter	20 g	50,000 per quarter	.....
Cedartown	88	11½ c	8,500 per mo.	7 c	8,500 per mo.	($1.135a)
La Grange	100	30 g	20,000 per mo.	10 g	1,000,000 per mo.	($21.53e)
Thomasville	100	18 g	.....	18 g	.....	.....
Idaho.						
Weiser	100	20 c	750 per mo.	8 c	6,750 per mo.	.....
Illinois:						
Harvey	100	22 ch	1,000 per mo.	14 ch	10,000 per mo.	.....
Hillsboro	100	40 g	5,000 per mo.	9 g	200,000 per mo.	($2.00a)
Lake Forest	100	21 g	.....	21 g	.....	($14.25f)
Mattoon	90	30 g	2,000 per mo.	.....	.....	7
Naperville	100	20 c	12,500 per quarter	15 c	12,500 per quarter	($13.38f)
Oak Park	100	18 g	100,000 per quarter	15 g	600,000 per mo.	16.5
Olney	99	37 g	7,200 per quarter	.....	.....	30
Pinckneyville	i	50 g	4,500 per quarter	8½ g	6,000,000 per mo.	.....
Quincy	80	45 g	10,000 per quarter	8 g	4,000,000 per mo.	.....
Rock Island	60	14 c	10,000 per quarter	6 c	40,000 per quarter	.....
Springfield	..	15 c	2,000 per mo.	6 c	30,000 per mo.	.....
Streator	60	30 c	1,000 per mo.	7.8 c	100,000 per mo.	9.4
West Chicago	100	42 g	3,000 per quarter	25 g	3,000 per quarter	.....
Indiana:						
Aurora	100	45 g	10,000 per mo.	10 g	100,000 per mo.	($2.35a)
Batesville	100	30 g	3,000	8½ g	4,500,000	.....
Columbia City	80	.....	.....	.....	.....	.....
Connersville	100	13 c	1,000 per mo.	4 c	200,000 per mo.	.....
Elkhart	94	12 g	80,000 per yr.	8 g	160,000 per mo.	($10.00e)
Greenfield	67	20 g	10,000 per quarter	.....	.....	.....
Greensburg	100	45 g	15,000 per mo.	20 g	60,000 per mo.	.....
Jasper	100	20 g	30,000 per yr.	10 g	360,000 per day	.....
Lebanon	99.3	25 g	90,000 per quarter	14 g	450,000 per quarter	21
Linton	25	35 g	15,000 per mo.	10 g	300,000 per mo.	22.5
Muncie	65	25 g	100,000	6¼ g	1,000,000	22
Nappanee	100	15 c	.....	15 c	.....	.....
Newcastle	50	12 c	2,000 per quarter	5½ c	50,000 per quarter	.....
Rensselaer	75	25 g	9,000 per quarter	5 g	979,000 per quarter	.....
Richmond	87.5j	20 c	1,500 per mo.	6.5 c	450,000 per mo.	13½
Rushville	100	20 c	.....	20 c	.....	.....
Seymour	45	30 g	4,000 per mo.	8 g	500,000 per mo.	.....
Shelbyville	85	25 g	5,000 per mo.	8 g	1,000,000 per mo.	.....

City	Percentage of Services Metered	Maximum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate: For Consumption Less than	Minimum Rate: Cents per 100 cu ft. (c) or 1,000 gal. (g)	Minimum Rate: For Consumption More than	Average Rate of all metered Water—Cents
Iowa:						
Albia	100	50 g	15,000 per mo.	.....	.....	30
Boone	100	37½ c	1,400 per quarter	8¼ c	100,000 per quarter	19.9
Burlington	6.2	30 g	.....	10 g	.....	14
Cedar Rapids	100	19 c	500 per mo.	5	102,000 per mo.	.....
Charles City	100	30 gk	.....	.....	.....	.....
Cherokee	100	50 g	4,000 per quarter	25 g	4,000 per quarter	.....
Dubuque	99⅞	25 c	1,000 per mo.	6 c	194,000 per mo.	.....
Ft. Dodge	100	45 g	5,000 per quarter	10 g	200,000 per quarter	.....
Ft. Madison	75	96 g	5,000 per mo.	.....	.....	.....
Hawarden	98	35 c	.....	.....	.....	.....
Independence	100	25 g	.....	25 g	.....	.....
Indianola	100	50 g	.....	30 g	.....	.....
Marshalltown	95	27 c	500 per quarter	6½ c	400,000 per quarter	11
Mason City	100	50 g	.....	15 g	700,000 per quarter	($2.60f)
Muscatine	..	25 c	1,400 per mo.	5 c	66,700 per mo.	.....
Sioux City	100	.....	.....	.....	.....	.....
Vinton	95	30 c	650 per quarter	15½ c	2,600 per quarter	26
Kansas:						
Abilene	100	25 c	2,000 per quarter	5 c	100,000 per quarter	.....
Anthony	100	33½ g	3,000 per mo.	15 g	10,000 per mo.	.....
Cherryvale	100	60 g	2,000 per mo.	12 g	200,000 per mo.	.....
Coffeyville	100	25 g	20,000 per mo.	7 g	1,000,000 per mo.	15
Columbus	98	40 g	10,000 per mo.	20 g	50,000 per mo.	35
Emporia	100	25 g	25,000 per mo.	8½ g	10,000,000 per mo.	.....
Garden City	75	10 g	.....	10 g	.....	.....
Herington	100	40 g	5,000 per mo.	10 g	.....	.....
Humboldt	100	35 g	5,000 per mo.	.....	.....	.....
Hutchinson	100	30 g	15,000 per mo.	5 g	1,000,000 per mo.	$20.65e)
Junction City	100	18¾ c	2,000 per mo.	8 c	200,000 per mo.	15
Mulberry	90	30 g	1,000 per mo.	15 g	500,000 per mo.	21
Neodesha	100q	25 g	.....	25 g	.....	.....
Newton	100	25 c	300 per mo.	11 c	13,300 per mo.	.....
Ottawa	1001	25 c	400 per mo.	4½ c	100,000 per mo.	.....
Paola	100	45 g	30,000 per quarter	15 g	90,000 per quarter	40
Kentucky:						
Ashland	100	35 g	30,000 per mo.	10 g	1,000,000 per mo.	28.4
Glasgow	100	50 g	15,000 per mo.	.....	.....	.....
Henderson	8	15 g	m	5 g	.....	6.9
Hopkinsville	65	36 g	30,000 per mo.	9.6 g	200,000 per mo.	22.2
Lexington	100	25 g	25,000 per mo.	10 g	500,000 per mo.	.....
Louisville	10.6	15 g	5,000 per day	6 g	45,000 per day	12
Maysville	5	40 g	1,000	16 g	100,000	.....
Middlesboro	44	35.1 g	25,000 per mo.	.....	.....	.....
Paris	..	25 g	1,000 per mo.	20 g	5,000 per mo.	.....
Louisiana:						
Rayne	100	20 g	20,000 per mo.	12 g	100,000 per mo.	15
Maine:						
Calais	20	40 c	.....	40 c	.....	.....
Kittery	50	14.5 c	.....	14.5 c	.....	.....
Pittsfield	75	1.50g	18,000 per quarter	33 g	18,000 per quarter	($3.00f)
Rockland	20	30 c	2,000 per mo.	10 c	10,000 per mo.	30
Skowhegan	95	22½ c	.....	.....	.....	.....
Maryland:						
Baltimore	18	.....	.....	.....	.....	.....
Chestertown	67	30 g	15,000	7½ g	150,000	.....
Hagerstown	92	30 g	3,333 per mo.	8½ g	5,000,000 per mo.	12
Massachusetts:						
Adams	0.4	10 g	150,000 in 6 mos.	4 g	150,000 in 6 mos.	.....
Brockton	98	19 c	18,000 per quarter	10 c	27,000 per quarter	15.7
Danvers	15	20 c	16,667 per quarter	10 c	100,000 per quarter	.....
East Bridgewater	95	22 c	1,200 in 6 mos.	.....	.....	.....
Fitchburg	99	.....	.....	.....	.....	.....
Melrose	100	20 c	10,000 per year	15 c	15,000 per year	($9.00e)
Northampton	99	12 c	10,000 per quarter	4½ c	100,000 per quarter	($18.83d)
North Andover	94.7	20 c	2,000 per quarter	12	2,000 per quarter	17.6
N. Attleborough	100	30 g	10,000 per year	8 g	.....	.....
Salisbury	1	40 g	.....	.....	.....	.....
S. Hadley Falls	8	15 gn	300,000 in 6 mos.	10 gn	300,000 in 6 mos.	.....
Spencer	90	20 c	5,000 per quarter	5 c	10,000 per quarter	.....
Springfield	99.2	22 c	5,000 per quarter	5 c	5,000 per quarter	13.7
Swampscott	100	30 c	.....	30 c	.....	.....
Taunton	90	19 c	10,000 per quarter	6¾ c	100,000 per quarter	15
Winthrop	100	16½ c	6,667 per year	.....	.....	.....
Michigan:						
Albion	100	15 c	1,500 per quarter	7½ c	13,333 per quarter	14.3
Ann Arbor	100	15 c	1,500 per quarter	6 c	100,000 per quarter	.....
Benton Harbor	100	25 g	10,000 per quarter	.....	.....	.....
Cheboygan	100	25 g	25,000 per mo.	20 g	25,000 per mo.	.....
Detroit	99.1	13 c	10,000 per quarter	4 c	100,000 per quarter	6
Dowagiac	100	15 c	3,000 per quarter	6 c	12,000 per quarter	10
Houghton	100	12 ch	40,000 per quarter	10 ch	40,000 per quarter	.....
Jackson	100	10 c	5,000 per quarter	7½ c	5,000 per quarter	.....
Ludington	90	10 c	.....	10 c	.....	10
Marshall	85	20 c	6,000 per year	8 c	200,000 per year	12½
Monroe	98	45 g	37,000 per quarter	9 g	961,500 per quarter	18
Mt. Clemens	100	15 c	2,000 per mo.	11 c	6,000 per mo.	($1.50a)
Negaunee	60	13 g	50,000 per quarter	7 g	50,000 per quarter	.....
Niles	100	12 c	6,000 per quarter	.....	.....	($2.25f)
Otsego	100	12 g	20,000 per year	6 g	100,000 per year	.....
Rochester	89	9 c	2,000 per quarter	5 c	2,000 per quarter	.....
St. Johns	33	90 g	3,000 per quarter	19 g	3,000 per quarter	.....
Traverse City	85	.....	.....	.....	.....	.....
Minnesota:						
Anoka	98	15 ck	333 per mo.	6 ck	1,200 per mo.	.....
Bemidji	100	30 g	20,000 per quarter	11 g	400,000 per quarter	.....
Brainerd	100	50 g	100,000 per mo.	10 g	200,000 per mo.	($1.95a)
Cloquet	100	50 g	1,000 per mo.	9 g	300,000 per mo.	36½
Crookston	100	45 g	.....	10 g	.....	.....

City	Percentage of Services Metered	Maximum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate: For Consumption Less than	Minimum Rate: Cents per 100 cu ft. (c) or 1,000 gal. (g)	Minimum Rate: For Consumption More than	Average Rate of all metered Water—Cents
Minnesota (Continued)						
Int'national Falls	100	30 g	5,000 per quarter	15 g	70,000 per quarter	($5.57f)
Lake City	100	30 c	3,000 per month	.....	.....	($1.25a)
Minneapolis	100	8 g	.....	8 g	.....	.....
Rochester	98	30 c	6,000 per quarter	8 c	9,000 per quarter	10
Staples	100	.....	1,000 per quarter	10 c	30,000 per quarter	.....
W. Minneapolis	95	15 c	50,000 per year	.....	.....	.....
Mississippi:						
Canton	100	20 c	1,000 per mo.	6 c	100,000 per mo.	($1.15a)
Jackson	75	25 g	.....	10 g	.....	.....
New Albany	90	35 g	.....	.....	.....	.....
Vicksburg	36	1.00g	2,250 per mo.	40 g	30,000 per mo.	.....
Missouri:						
Columbia	100	30 c	.....	30 c	.....	.....
Liberty	100	40 g	20,000	25 g	40,000	.....
St. Charles	4½	.....	.....	.....	.....	.....
Montana.						
Billings	100	25 c	1,000 per mo.	5 c	200,000 per mo.	11
Kalispell	85	40 g	3,000 per mo.	10 g	3,000 per mo.	20
Missoula	5	26 c	5,000 per mo.	.....	.....	.....
Nebraska:						
Fremont	..	15 c	10,000 per quarter	7½ c	60,000 per quarter	12
Hastings	100	16 c	10,000 per year	10 c	90,000 per year	11¼
Havelock	98	25 g	5,000 per mo.	20 g	5,000 per mo.	($0.70a)
Holdrege	100	18 c	10,000 per mo.	.....	.....	.....
Lincoln	100	15 g	....	15 g	.....	.....
Superior	100	25 g	57,000 per mo.	11 g	157,000 per mo.	.....
New Hampshire:						
Claremont	76	15 c	.....	15 c	.....	.....
Lebanon	33	.....	.....	.....	.....	.....
New Jersey:						
Belleville	75	21½ c	2,000	18½	2,000	.....
Dover	100	33 c	1,000 per quarter	24 c	5,000 per quarter	30
Hackensack Water Co. (serves 47 municipalities)	100	24 ch	40,000 per year	10 ch	4,000,000 per year	.....
Madison	100	26 cs	12,000 per quarter	19 cs	12,000 per quarter	.....
	100	22½ c	12,000 per quarter	14 c	12,000 per quarter	.....
Montclair	100	29 cz	10,000 per month	14½ cz	1,000,000 per quarter	23.8
Newton	85	30 g	5,000 per quarter	11 g	2,000,000 per quarter	.....
Nutley	100	30 c	.....	12½ c	10,000 per quarter	24
Red Bank	100	30 c	50,000 per quarter	.....	.....	.....
Washington	..	16 ch	5,000 per quarter	5 ch	100,000 per quarter	.....
New York:						
Auburn	99.9	13 c	1,000 per mo.	4 c	38,000 per mo.	8½
Binghamton	100q	10 c	4,000 per mo.	6 c	24,000 per mo.	.....
Carthage	60	36 c	8,000 in 6 mos.	5.4 c	50,000 in 6 mos.	.....
Catskill	18	10 c	.....	.....	.....	.....
Clyde	50	62½ g	600 per quarter	12½ g	5,000 per quarter	.....
Dansville	1	12 g	9,000 per mo.	2 g	3,000,000 per mo.	6
East Syracuse	99	20 c	.....	.....	.....	.....
Elmira	100	30 c	500 per quarter	5½ c	1,200,000 per mo.	23
Fairport	95	23 c	8,000 per quarter	12 c	24,000 per quarter	.....
Fort Plain	..	17 ck	1,500 per quarter	2 ck	15,000 per quarter	.....
Geneva	100	25 c	1,300 per quarter	6 c	14,000 per quarter	.....
Jamestown	100	20 c	.....	20 c	.....	.....
Lowville	98	20 c	1,200 in 6 mos.	.....	.....	.....
Malone	1	30 g	10,000 per quarter	5 g	385,000 per quarter	.....
Middletown	3	7½ c	2,000 per mo.	2½ c	16,000 per mo.	.....
Olean	100	15½ c	900 per quarter	5½ c	60,000 per quarter	11½
Ossining	98	20 c	Domestic	10 c	Manufacturing	.....
Oswego	10	25 g	36,000 per mo.	3½ g	2,250,000 per mo.	6¼
Port Jervis	..	16 g	200,000 per year	2½ g	500,000 per day	.....
Rensselaer	75	25 c	2,000	9 c	10,000	.....
St. Johnsville	100	16 c	1,600 per quarter	4 c	100,000 per quarter	9
Scarsdale	100	28 c	10,000 per quarter	17½ c	200,000 per quarter	.....
Seneca Falls	9	40 c	1,000 per mo.	10 c	15,000 per mo.	.....
Syracuse	100t	14 c	10,000 per mo.	7 c	10,000 per mo.	.....
Tarrytown	99	31 c	5,000 per quarter	22½ c	300,000 per quarter	($2.64f)
Waterford	100	30 g	1,000 per day	12 g	20,000 per day	24.4
Watkins Glen	100	20 c	4,000 per quarter	15 c	4,000 per quarter	.....
Wellsville	80	25 c	7,500 per quarter	8 c	20,000 per month	.....
North Carolina.						
Greensboro	90	25 c	1,500 per mo.	10 c	14,000 per month	.....
High Point	100	24¾ c	300 per mo.	11 c	60,000 per mo.	.....
Kinston	100	30 g	10,000 per mo.	16 g	60,000 per mo.	.....
Mooresville	100	30 g	20,000 per mo.	.....	.....	($1.00a)
Raleigh	57.7	30 g	25,000 per mo.	12 g	1,000,000 per mo.	.....
Rocky Mount	100	37½ c	800 per quarter	6 c	100,000 per quarter	.....
Troy	100	62½ g	2,000 per mo.	30 g	100,000 per mo.	.....
North Dakota:						
Fargo	100	15 g	250,000 per mo.	10 g	1,000,000 per mo.	12
Minot	100	75 g	1,000 per mo.	15 g	500,000 per mo.	.....
Ohio:						
Akron	100	16 c	20,000 per mo.	12	80,000 per mo.	.....
Canton	100	10 c	20,000 per quarter	7½	40,000 per quarter	.....
Chillicothe	75	20 g	.....	.....	.....	.....
Cincinnati	100u	12 c	.....	12 c	.....	12
Columbus	99+	12 c	25,000 per mo.	6 c	2,000,000 per mo.	($22.29e)
Conneaut	99	40 g	30,000 per mo.	.....	.....	.....
E. Liverpool	20	55 g	5,000 per quarter	10 g	200,000 per quarter	.....
Eaton	80	37½ g	32,000 per quarter	25 g	.....	.....
Fostoria	100	15 c	3,500 per mo.	6¾ c	50,000 per mo.	($1.35a)
Gibsonburg	100	30 c	100 per day	20 c	500 per day	($12.00e)
Huron	100	25 c	1,000 per quarter	15 c	1,000 per quarter	.....
Kent	100	28 c	1,000 per quarter	10 cv	10,000 per quarter	($2.00f)
Lakewood	100	12 c	.....	12 c	.....	12.4d
Marietta	40	30 g	500 per day	12 g	10,000 per day	.....
Medina	100	60 c	500 per quarter	10 c	7,100 per quarter	($4.47f)

City	Percentage of Services Metered	Maximum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate: For Consumption Less than	Minimum Rate: Cents per 100 cu ft. (c) or 1,000 gal. (g)	Minimum Rate: For Consumption More than	Average Rate of all metered Water—Cents
Ohio (Continued)						
Middletown	100	12½ c	1,000 per quarter	6 c	20,000 per quarter	.....
Milan	50	10 g	.....	10 g	.....	.....
Mingo Junction	60	45 g	25,000 per mo.	.....	.....	($3.64f)
Montpelier	85	27 c	1,000 per quarter	6.3 c	10,000 per quarter	15
Niles	100	.....	.....	.....	.....	.....
Portsmouth	16	25 g	25,000 per quarter	10 g	550,000 per quarter	18.2
Ravenna	25	23½ c	1,290 per quarter	8.4 c	40,000 per mo.	.....
Shelby	100	60 g	5,000 per quarter	15 g	1,000,000 per mo.	18
Sidney	100	29 c	4,000 per quarter	10½ c	70,000 per quarter	.....
Struthers	100	20 c	5,000 per quarter	8 c	45,000 per quarter	($15.13)
Troy	100	.....	.....	.....	.....	.....
Warren	100w	36 c	2,400 per quarter	14.4 c	12,000 per quarter	.....
Wilmington	100	25 g	.....	25 g	.....	25
Oklahoma:						
Guthrie	100	25 g	30,000 per mo.	15 g	180,000 per mo.	.....
Pennsylvania:						
Bradford	10	9 g	1,000,000 per quarter	6 g	2,000,000 per quarter	9
Catasauqua	2	30 c	300	5 c	40,000	.....
Chester	100	30 g	25,000 per mo.	10 g	2,500,000 per mo.	.....
Clearfield	90	20 g	25,000 per quarter	4 g	500,000 per quarter	11.9
Connellsville	35	33 g	3,000 per quarter	12 g	300,000 per mo.	.....
Duquesne	100	40 g	.....	30 g	.....	.....
Emporium	100	60 c	.....	20 c	44,000 per quarter	60
Hanover	5	57 g	3,500 per quarter	10 g	3,000,000 per quarter	.....
Huntingdon	x	15 g	100,000 per mo.	6 g	600,000 per mo.	11+
Jersey Shore	5	25 g	100,000 per quarter	2 g	20,000,000 per quarter	12
Midland	100	30 c	3,000 per quarter	10 c	23,000 per quarter	.....
Reading	100	8 c	.....	8 c	.....	.....
Schuylkill Haven	100	50 g	75,000 per quarter	15 g	725,000 per quarter	($16.25f)
Shamokin	10	80 g	1,000	10 g	50,000	10+
Sharpsville	100	30 g	.....	.....	.....	.....
Susquehanna	0.5	40 g	90,000 per quarter	15 g	200,000 per quarter	33
Uniontown	100	25 g	50,000 per mo.	10 g	500,000 per mo.	.....
Rhode Island:						
Bristol & Warren	4	40 g	50,000 per mo.	15 g	2,000,000 per mo.	19.5
South Carolina:						
Anderson	100	25 g	20,000 per mo.	15 g	100,000 per mo.	.....
Batesburg	100	50 g	2,000 per mo.	.....	.....	.....
Cheraw	100	37 g	3,000 per mo.	15 g	50,000 per mo.	($2.50a)
Easley	100	20 g	15,000 per mo.	7½ g	1,000,000 per mo.	15—17½
South Dakota.						
Mitchell	100	20 c	500 per quarter	8½ c	50,000 per quarter	.....
Watertown	99.5	28 c	5,000 per quarter	7½ c	106,000 per quarter	.....
Tennessee:						
Lebanon	87	40 c	800 per mo.	20 c	30,000 per mo.	.....
Maryville	100	16⅔ g	3,000 per mo.	10 g	50,000 per mo.	.....
Memphis	100	25½ c	1,000 per mo.	8½ c	50,000 per mo.	($2.25a)
Texas:						
Bay City	78	75 g	2,000 per mo.	35 g	2,000 per mo.	.....
El Paso	100	22½ g	100,000 per mo.	14 g	1,000,000 per mo.	17.4
Ennis	90	40 g	10,000 per mo.	25 g	60,000 per mo.	30
Hillsboro	86	45 g	15,000 per mo.	.....	.....	40
Longview	..	45 g	10,000 per mo.	14 g	800,000 per mo.	22
Mart	95	75 g	2,000 per mo.	15 g	200,000 per mo.	.....
Mexia	85	62½ g	2,000 per mo.	40 g	7,000 per mo.	51
Yoakum	60	30 g	3,300 per mo.	18 g	3,300 per mo.	.....
Utah:						
Toole	8	15 g	.....	15 g	.....	.....
Vermont:						
Bennington	Few	30 g	.....	.....	.....	.....
Fair Haven	Commercial	25 g	10,000 in 6 mos.	10 g	50,000 in 6 mos.	.....
Newport	..	20 g	40,000 per year	10 g	209,000 per yr.	.....
Virginia:						
Charlottesville	75	.....	.....	.....	.....	.....
Lynchburg	72	17.85c	Domestic	6 c	Industrial	15.8
Richmond	95	11 c	10,000 per mo.	5 c	30,000 per mo.	.....
Washington:						
Aberdeen	12½	30 c	1,000 per mo.	5 c	100,000 per mo.	12
Bellingham	16	25 c	400 per mo.	2 c	2,000,000 per mo.	.....
Centralia	19.3	22.52c	444 per mo.	.....	.....	.....
Dayton	100	16⅔ c	600	6⅔ c	900	.....
Olympia	90	26¼ c	600 per mo.	.....	.....	($1.25a)
Pullman	100	25 g	4,000 per mo.	15 g	4 000 per mo.	.....
Raymond	70	72½ g	2,000 per mo.	7¼ g	1,000,000 per mo.	.....
Ritzville	100	1.00g	2,000 per mo.	15 g	2,000 per mo.	($2.75a)
South Bend	85	33⅓ c	600	6 c	10,000	.....
Walla Walla	42	25 g	1,000 per mo.	8 g	1,000,000 per mo.	.....
Winlock	50	43¾ c	800 per mo.	15 c	20,000 per mo.	.....
West Virginia.						
Charleston	100	30 g	10,000 per mo.	.....	.....	.....
Follansbee	100	60 g	6 000 per quarter	20 g	40,000 per quarter	.....
Salem	85	90 g	15,000 per quarter	62½ g	15,000 per quarter	81
Sistersville	3½	35 g	25,000 per quarter	7¼ g	1,200,000 per quarter	20
Welch	100	67½ g	3,000 per mo.	35 g	50,000 per mo.	.....
Weston	100	49.5 g	10,000 per quarter	12.6 g	200,000 per quarter	23.4
Wisconsin:						
Antigo	40	35.7 c	700	6 c	.....	.....
Appleton	100	22 ch	500 per quarter	2 ch	1,000,000 per quarter	.....
Chippewa Falls	60	36 g	9,000 per mo.	7.2 g	900,000 per mo.	.....
Cudahy	100	8 c	100,000 per mo.	.....	.....	.....
Fond du Lac	97	.....	.....	.....	.....	.....
Hartford	..	21.5 g	11,600 per quarter	12 g	26,600 per quarter	.....
Janesville	100	.....	.....	.....	.....	.....
Ladysmith	55	35 g	.....	.....	.....	.....
Madison	99.87	7½ c	75.000 in 6 mos.	4 c	500,000 in 6 mos.	7
Lancaster	..	40 g	10,000 per quarter	25 g	30,000 per quarter	.....
Manitowoc	100	22 c	2,500 per mo.	4 c	25.000 per mo.	8
Menasha	100	15 g	60,000 per quarter	2½ g	27,450,000 per mo.	5

City	Percentage of Services Metered	Maximum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate: For Consumption Less than	Minimum Rate: Cents per 100 cu ft. (c) or 1,000 gal. (g)	Minimum Rate: For Consumption More than	Average Rate of all metered Water—Cents
Wisconsin (Continued)						
Milwaukee	100	7 ch 10 cs	....	7 ch 10 cs	....	} 8
Neenah	100	30ghy	9,000 per quarter	16 gh	45,000 per quarter	.....
Shawano	100	18 c	3,600 per mo.	6½ c	65,000 per mo.	.....
S. Milwaukee	100	25 g	25,000 per quarter	10 g	100,000 per quarter	($2.77f)
Watertown	98	16½ c	750 per quarter	4¼	50,000 per quarter	.....

a—Average per meter per month. b—$2.00 minimum bill. d—Due to minimum charge. e—Average per meter per year. f—Average per meter per quarter. h—Plus service charge. i—Meter rates adopted but no domestic meters installed yet. j—Will be 100 per cent. by 1927. k—Plus meter rental. l—All metered except city departments. m—Rate based on classification and not on consumption basis. n—20 per cent. discount 30 days. p—Plus service charge of $12 to $30. q—Municipal consumption not metered. r—Discount equals double the thousands of cu. ft.; ex. 6 per cent. for 3,000 cu. ft. s—Outside city limits. t—Of domestic services. u—Of revenue producing services. v—Domestic rates given; industrial rates for low pressure 2nd quality water 10c for first million gals., 4c for all over 5 million. w—All but fire lines. x—Only factories, schools and hotels. y—Fire protection service, from $50 per year for 3" meter to $140 for 8", plus regular rates for water. z—These rates for high (re-pumped) service. For low service, rates are 21 and 10½ respectively.

Chemicals Used in Water Purification

City	Chemicals Used
Alabama:	
Gadsden	Liquid chlorine, alum, lime
Arkansas.	
Benton	Hypochlorite, alum, soda ash
Malvern	Alum
Rogers	Liquid chlorine
Colorado:	
Colorado Springs.	Liquid chlorine
Montrose	Liquid chlorine, copper sulphate
Connecticut:	
Baltic	Copper sulphate (very little)
Bridgeport	Liquid chlorine, copper sulphate
Danielson	Iron sulphate
Darien	Liquid chlorine
Putnam	Liquid chlorine, alum
So. Manchester	Liquid chlorine, alum; copper sulphate at times
Westport	Liquid chlorine, copper sulphate
Willimantic	Liquid chlorine
Georgia:	
Cedartown	Liquid chlorine
La Grange	Liquid chlorine, alum, soda ash
Idaho:	
Weiser	Liquid chlorine
Illinois:	
Lake Forest	Liquid chlorine, alum
Matton	Liquid chlorine, alum (at times)
Mt. Carmel	Liquid chlorine, alum
Naperville	Liquid chlorine (at times)
Oak Park	Liquid chlorine
Pinckneyville	Liquid chlorine, alum, lime
Quincy	Liquid chlorine, alum, lime
Rock Island	Liquid chlorine, alum
Springfield	Liquid chlorine
Streator	Liquid chlorine, alum, hydrated lime, copper sulphate (perhaps)
Indiana:	
Aurora	Liquid chlorine, alum
Jasper	Liquid chlorine, alum
Lebanon	Liquid chlorine
Muncie	Liquid chlorine, alum
Richmond	Liquid chlorine, (slightly)
Seymour	Liquid chlorine, alum, copper sulphate (at times)
Shelbyville	Liquid chlorine
Iowa.	
Albia	Liquid chlorine, alum, lime
Boone	Liquid chlorine
Burlington	Liquid chlorine, alum, lime (will probably)
Cedar Rapids	Liquid chlorine, copper sulphate, alum
Cherokee	Liquid chlorine
Dubuque	Liquid chlorine
Ft. Madison	Liquid chlorine, alum
Marshalltown	Liquid chlorine
Muscatine	Liquid chlorine, copper sulphate
Sioux City	Liquid chlorine, (at times)
Kansas:	
Anthony	Liquid chlorine
Cherryvale	Liquid chlorine, copper sulphate, alum
Coffeyville	Liquid chlorine, alum, hydrated lime
Emporia	Liquid chlorine, alum, lime
Herington	Liquid chlorine, copper sulphate, alum
Humboldt	Liquid chlorine, copper sulphate, alum, lime
Junction City	Liquid chlorine
Neodesha	Liquid chlorine, alum
Ottawa	Liquid chlorine, iron sulphate, alum, hydrated lime, copper sulphate (at times)
Paola	Liquid chlorine, alum
Kentucky:	
Glasgow	Liquid chlorine
Henderson	Liquid chlorine, alum, iron sulphate at times
Hopkinsville	Liquid chlorine, alum
Lexington	Liquid chlorine, copper sulphate, alum
Louisville	Liquid chlorine, copper sulphate alum
Maysville	Liquid chlorine, alum, soda ash
Middlesboro	Liquid chlorine
Maine:	
Caribou	Liquid chlorine
Livermore Falls	Liquid chlorine
Pittsfield	Liquid chlorine
Rockland	Liquid chlorine, copper sulphate at times
Skowhegan	Liquid chlorine
Maryland:	
Baltimore	Hypochlorite, liquid chlorine, iron sulphate or alum, copper sulphate
Hagerstown	Liquid chlorine, alum
Massachusetts:	
North Andover	Liquid chlorine
Springfield	Alum
Michigan:	
Ann Arbor	Liquid chlorine
Benton Harbor	Liquid chlorine, alum
Detroit	Liquid chlorine, alum
Houghton	Liquid chlorine
Jackson	Liquid chlorine
Ludington	Hypochlorite
Monroe	Liquid chlorine, alum
Mount Clemens	Hypochlorite
Negaunee	Liquid chlorine
Niles	Liquid chlorine
Traverse City	Liquid chlorine
Minnesota.	
Cloquet	Liquid chlorine
Crookston	Liquid chlorine, alum
International Falls	Liquid chlorine
Minneapolis	Liquid chlorine, alum
Rochester	Liquid chlorine, (half of supply)
Mississippi:	
Canton	Liquid chlorine
Jackson	Liquid chlorine, alum
Vicksburg	Liquid chlorine, iron sulphate, hydrated lime
Missouri:	
Liberty	Liquid chlorine, alum, lime
St. Charles	Liquid chlorine, alum, lime
Montana:	
Billings	Liquid chlorine, alum
Missoula	Liquid chlorine
Nebraska:	
Lincoln	Liquid chlorine
Superior	Liquid chlorine, copper sulphate, alum, lime, soda ash
New Hampshire:	
Claremont	Liquid chlorine
Lebanon	Liquid chlorine, alum
New Jersey:	
Dover	Liquid chlorine,
Hackensack Wat. Co. (47 municipalities)	Liquid chlorine copper sulphate, alum, lime sometimes
Helmetta	Permutit
Washington	Liquid chlorine
New York.	
Auburn	Liquid chlorine
Binghamton	Liquid chlorine, alum
Canton	Liquid chlorine
Catskill	Liquid chlorine
Danville	Liquid chlorine.
East Syracuse	Liquid chlorine
Elmira	Liquid chlorine, alum
Fairport	Copper sulphate, alum
Middletown	Copper sulphate, alum
Olean	Liquid chlorine, alum
Ossining	Liquid chlorine, copper sulphate
Oswego	Liquid chlorine
Port Jervis	Liquid chlorine, a copper sulphate

City	Chemicals Used
Rensselaer	Liquid chlorine, alum
Seneca Falls	Liquid chlorine, alum
Syracuse	Liquid chlorine, copper sulphate
Tarrytown	Liquid chlorine, copper sulphate, alum
Waterford	Liquid chlorine, alum, sulphuric acid, lime
Watkins Glen	Liquid chlorine
Wellsville	Liquid chlorine, alum, soda ash
North Carolina:	
Greensboro	Liquid chlorine, alum
High Point	Liquid chlorine, alum
Mooresville	Liquid chlorine, copper sulphate, alum, soda ash
Raleigh	Liquid chlorine, copper sulphate, alum
Rocky Mount	Hypochlorite, liquid chlorine, alum soda when necessary
Troy	Liquid chlorine, alum, lime
North Dakota:	
Fargo	Liquid chlorine, iron sulphate, hydrated lime; copper sulphate and alum occasionally
Ohio:	
Akron	Liquid chlorine, alum, lime
Cincinnati	Liquid chlorine, iron sulphate, lime
Columbus	Liquid chlorine, alum, lime, soda ash
Conneaut	Liquid chlorine, alum
East Liverpool	Liquid chlorine, lime
Eaton	Liquid chlorine, alum
Huron	Hypochlorite, alum
Marietta	Liquid chlorine, alum, lime
Medina	Liquid chlorine, copper sulphate, alum, lime, soda ash
Mingo Junct.	Liquid chlorine
Niles	Liquid chlorine, iron sulphate, lime
Portsmouth	Liquid chlorine, alum
Ravenna	Liquid chlorine, copper sulphate, alum
Struthers	Liquid chlorine, copper sulphate, alum, lime
Warren	Hypochlorite, liquid chlorine, alum
Oklahoma:	
Guthrie	Liquid chlorine, iron sulphate, lime, copper sulphate (very little)
Pennsylvania:	
Beaver	Liquid chlorine
Chester	Liquid chlorine, alum
Connellsville	Hypochlorite, liquid chlorine, alum lime
Duquesne	Lime
Emporium	Hypochlorite, copper sulphate
Hanover	Hypochlorite
Huntingdon	Hypochlorite
Jersey Shore	Liquid chlorine
Midland	Hypochlorite, iron sulphate, lime
Milville	Liquid chlorine
Reading	Liquid chlorine, copper sulphate
Schuylkill Haven.	Copper sulphate
Shamokin	Liquid chlorine
Sharpsville	Hypochlorite
Susquehanna	Liquid chlorine, copper sulphate
Uniontown	Hypochlorite
Rhode Island:	
Bristol & Warren.	Liquid chlorine, alum, whiting
South Carolina.	
Anderson	Liquid chlorine, alum
Cheraw	Hypochlorite, alum, soda ash
Easley	Liquid chlorine, copper sulphate, (sometimes), alum, lime
South Dakota:	
Watertown	Liquid chlorine, alum, lime
Tenessee:	
Lebanon	Liquid chlorine
Maryville	Liquid chlorine
Texas:	
Ennis	Liquid chlorine
Hillsboro	Liquid chlorine
Longview	Liquid chlorine alum, iron sulphate, lime
Mexia	Liquid chlorine, copper sulphate
Virginia:	
Charlottesville	Liquid chlorine
Clifton Forge	Liquid chlorine
Lynchburg	Liquid chlorine, copper sulphate, alum, soda ash
Richmond	Liquid chlorine, alum
Washington:	
Aberdeen	Liquid chlorine
Bellingham	Liquid chlorine
Centralia	Liquid chlorine
Olympia	Liquid chlorine
Raymond	Liquid chlorine
Walla Walla	Liquid chlorine
West Virginia:	
Charleston	Liquid chlorine, alum
Sistersville	Liquid chlorine, alum, lime
Welch	Liquid chlorine
Weston	Liquid chlorine, alum, soda ash
Wisconsin.	
Antigo	Liquid chlorine
Appleton	Liquid chlorine, copper sulphate, alum
Cudahy	Liquid chlorine
Madison	Liquid chlorine, (partial)
Manitowoc	Liquid chlorine
Milwaukee	Liquid chlorine
So. Milwaukee	Liquid chlorine, alum

a—Use liquid chlorine only when pumping from river; copper sulphate in distributing reservoir June, July, August and September.

Motor Vehicle Registrations and Revenues

Receipts from motor vehicle registration fees, number of vehicles of each class registered, and gasoline taxes, for the year 1925

Motor vehicle statistics for the year 1925 have been published by the Bureau of Public Roads in considerable detail for each of the states, tabulated under the heads, "Motor Vehicle Registration for the Year 1925"; "Receipts from Motor Vehicle Registration Fees, etc., for the Year 1925," and "Gasoline Taxes for the Year 1925."

These figures show that there were registered at the end of that year 19,954,347 motor cars and trucks, while 102,272 tax-exempt official vehicles were not included in this total.

Of the total registered cars, 2,441,709 were motor trucks and tractors, 145,530 were taxies and 57,826 were busses. (The last figure is believed to be incomplete.) The total number of motorcycles is given as 140,348.

Of the total registered motor vehicles, New York had more than any other one state—1,625,583; California coming second with 1,440,541, and Ohio, third, with 1,346,400. The same states lead in the same order in the list of passenger automobiles. On the basis of motor trucks and road tractors New York leads with 278,918, California comes second with 214,745 and Pennsylvania, third, with 181,339. Taxies being largely city vehicles, New York City and Chicago naturally bring their respective states into the lead; the former with 26,079 and the latter with 10,374. No other state approximates these figures, the nearest being Pennsylvania (undoubtedly due to Philadelphia) with 6,937.

In trailers, California leads with 27,542, the next highest being Michigan with 10,592, followed by Ohio with 9,000.

The total registration for the entire country increased last year 13.4 per cent. over 1924. Increases in the several states, however varied considerably Mississippi having shown the maximum increase—33.6 per cent. and South Carolina the minimum—4.2 per cent. Thirty-three states showed a percentage of increase ranging between 10 and 20.

The total receipts from motor vehicle registration fees for the year totaled $260,619,621. Of this total, $177,706,587 was spent for state highways, $48,396,471 for local roads and $19,124,014 for state road bonds, while $11,992,747 was consumed in

collection and administration costs. $3,399,802 went for other purposes, such as traffic officers' expenses (California), expenses of the state highway commission (Iowa, Maine and West Virginia), expenses of motor vehicle theft department (Michigan) and operation of auto theft law (Virginia), toll bridge commission (New Jersey).

Only thirty-three of the states reported the details of the gross receipts, the total for these states being $184,412,512. Of this amount, $161,574,729 was for motor car registration, $634,076 for trailers, $436,482 for motorcycles, and the balance for dealers' licenses, chauffeur and operator permits and other miscellaneous revenues.

Of the total gross receipts for fees, etc., New York state received the largest amount—$25,506,245 and Pennsylvania next, $21,926,972. Michigan was third with $14,526,002. California, which was second in number of registrations, is well down the list in gross receipts, its total being $7,816,298.

The table of gasoline taxes showed that the total tax earnings on fuel for motor vehicles during the year was $146,028,940. Four states collect no tax on gasoline, these being Illinois, Massachusetts, New Jersey and New York. The largest collection was made by California, $14,956,789. Ohio was second with $9,009,950 and Pennsylvania third with $8,352,798.

Of the total tax earnings, $102,065,216 was spent on the construction and maintenance of state highways, and $32,721,704 of local roads; while $217,393 was required for collection costs and $11,024,627 was disposed of for other purposes, being placed in the state treasury in Georgia, Montana, North Dakota and Pennsylvania, and for special purposes such as the maintenance of Baltimore streets in Maryland, a sea wall in Harrison County, Mississippi, maintenance of municipal streets in Ohio, and the free school fund in Texas.

The total net gallons of gasoline taxed and used by motor vehicles is given as 6,457,783,284; in addition to which there was used in the states where gasoline is not taxed and in other states (where certain amounts for some reason were not taxed), a total of 2,131,056,365; giving a total of 8,589,000,000 gallons reported as being used by motor vehicles.

Nebraska Highway Specifications

M. C. Noble, chief of the Bureau of Roads and Bridges of the state of Nebraska, has sent to contractors a letter calling attention to certain changes in the highway specifications applicable to work for 1926. The more important of these changes are as follows:

Loose rock classification has been dropped and will be included under common excavation, there being only one other class—solid rock. But excavation for culverts and bridges will be under three classes—solid rock, wet, and common excavation.

Bids will be taken separately for concrete base with curb as one item and the wearing course as another but both items will go to one contractor.

The gravel surfacing which has been so successful in Nebraska has been termed "sand gravel surfacing" by the federal bureau because of its fineness. "As formerly, the basic requirements are 70 per cent on a number 10 sieve, but material testing as low as 55 per cent. may be used if reinforced by adding the proper per cent. to produce the required 70 per cent. retention of a number 10 sieve." Clay content must not exceed 20 per cent.

Concrete paving mixers in the future shall be equipped with a boom and bucket delivery in lieu of the spout or chute formerly permitted.

The federal bureau has required that no cement base paint be used on any federal aid contracts, but its use will continue to be permitted on state aid contracts. It is stated that the shop coat with this paint is considerably cheaper than using lead base paints.

Former classes of concrete A, B, C and D have been changed to AA, A, B and D respectively, to conform to the general federal classifications. All concrete deposited under water shall be class A with 5 per cent. excess cement.

Concrete culvert pipe shall develop an ultimate strength of 1,500 D when it is tested by the 3-point method. All concrete pipe larger than 18-inch diameter shall carry a double line of reinforcing. Copper steel corrugated pipe has been eliminated and Molybendum iron added. Bids will be received on vitrified clay pipe for culverts from 18 inches to 36 inches diameter, the pipe to show the same ultimate strength under the 3-point test as concrete pipe; but this pipe cannot be furnished in sizes larger than 36 inches.

Only two kinds of guard rail will be used, the woven wire supported by pressure treated posts, and 2-line cable with untreated posts.

Snow Removal on Nevada Highways

Keeping highways open across the Sierra Nevada Mountains is a problem that has occupied the attention of the Nevada Highway Department for several years past. Late in March it tested out a rotary plow on the Glenbrook road, which had been closed since the first storms of the winter. The road has an average grade of 10 per cent, and the snow was solidly packed to a depth of from two to six feet. The plow was driven by a 10-ton army type tractor. Previously the road had been opened laboriously by shovelers, and it is estimated that the plow did the work of 150 men.

PLOWING OUT A NEVADA HIGHWAY

The Department is confident that, with this plow in service, no difficulty will be experienced in keeping the roads open throughout the winter wherever traffic demands. It is believed that fresh snow can be cleared off quickly to a depth of four or five feet, and that by continuous use of the plow a road can be prevented from becoming blocked. The rotors of the plow throw the snow a considerable distance from the roadway, thus overcoming the disadvantages of the push plow.

The test was closely watched by highway officials and road enthusiasts, and it is probable that in another year a movement will be well under way to keep the two main routes across the Sierra open all year. The central route across the state from Fallon to Ely is becoming an important stage and freight artery and it is probable that the traffic in another year will warrant keeping the summits open on that route.

The test was highly instructive in that it demonstrated that ordinary conditions can be met successfully at moderate cost. The test on the Glenbrook road was severe in that the snow was closely packed and harder to handle than fresh snow. In addition, there was the hazard of running into rock slides and fallen trees. For this reason the plow was raised to a height of ten inches from the ground and the job was completed without accident or delay of any kind.

Passenger Transportation in City Streets

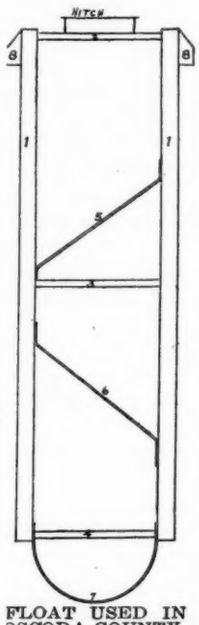
This subject is to be discussed by the American Society of Civil Engineers at its meeting on June 2, when John A. Miller, Jr., associate editor of *Electric Railway Journal*, will read a paper entitled "Increasing the Efficiency of Passenger Transportation in City Streets," which is published in the May issue of the Proceedings of the society.

In this paper Mr. Miller says that many plans for the relief of traffic congestion are based on the general theory of providing more roadway area to be used in exactly the same way that the existing street area is used. Cutting through new thoroughfares, widening present roadways, arcading sidewalks, double-decking arterial routes, and placing the electric railways underground are among the proposals made. Enormous expense would attend the execution of any of these plans. While it cannot be denied that substantial benefits would result, it is extremely doubtful whether permanent relief from traffic congestion would be attained. Experience has shown in a number of instances that new streets cut through to relieve overcrowding on older streets soon become congested themselves, without any marked diminution of traffic on the other streets. It seems, therefore, that the problem might well be approached from a different angle. By stimulating the more intensive use of present streets, a far larger volume of traffic could be moved through them without the necessity for huge expenditures on improvements.

This paper shows that the present general practice of using roadway space for the storage of private automobiles is in reality neither a convenience to the automobilists nor a benefit to the merchant. The elimination of parking in congested districts would greatly increase the roadway available for moving vehicles. The use of attractive common carrier vehicles can be developed to handle a large part of the traffic now requiring single passenger or two-passenger vehicles. A material reduction in congestion will thereby be effected without excessive cost. The movement of all traffic will be facilitated to a degree that will be advantageous to the users of public and private conveyances.

Float for Michigan Sand Roads

A float used on the sand roads in Oscoda County, Michigan, is described for us by W. E. Smith, superintendent of highway maintenance of the county. The float was made by J. C. Kreuzer of Luzerne and was used by him last summer to maintain 7½ miles of sandy road. It was used after each rain and the cost for the season was about $100, and Mr. Smith states that the road so maintained was one of the best in northern Michigan.



FLOAT USED IN OSCODA COUNTY, MICHIGAN

Mr. Smith describes the float as follows, referring to the sketch: Numbers 1-1 are two logs about 8 inches thick and 16 feet long, flattened on the sides. The rounding bottom of the log drags in the tracks. Numbers 2, 3 and 4 are 2x6 braces used to hold the runners in place. Numbers 5 and 6 are irons, for which 4-inch wagon tires are used, which are placed slanting across the float with one end a little higher than the other so as to make the road a little rounding. Number 7 is a piece of iron 4 inches wide bent to a semi-circle and fastened at each end with bolts through the runners so that it can work up and down; this being used to gather loose stones from the road bed. Numbers 8-8 are nose pieces made to shove the comb back from the rut.

Concrete Tests to Be Made in New Jersey

The New Jersey State Highway Department, in cooperation with the Bureau of Public Roads, has begun a series of concrete tests for the purpose of studying the relative concrete making properties of crushed stone and gravel used in concrete road construction in that State. The tests are being made in the State Highway Laboratory at Trenton, and involve the fabrication and testing of about 250 concrete beams 8

by 8 by 48 inches in size, as well as a large number of cylinders for compression tests.

The program calls for three series of tests. In the first series the workability of the concrete is to be kept constant, as nearly as possible, by means of the flow test, and the relative yield and strength of the concrete determined for each of several gradations of both crushed stone and gravel, using concrete proportions as given in the current New Jersey Standard Specifications. The object of this series is to determine the relative strength and yield of gravel concrete as compared with crushed stone concrete for several sizes and gradations of coarse aggregate.

In the second series an effort will be made to design concrete of a given strength by means of the water-cement ratio theory, for each type and gradation of coarse aggregate. The procedure to be followed in this series is essentially as follows. To each gradation and type of coarse aggregate, fine aggregate will be added in the following ratios by volume, 33 to 67, 36 to 64 and 40 to 60. To each of the above combinations, water and cement in fixed ratio, depending on the strength desired, will be added until the desired workability has been reached. The end point in each case will be determined by means of the flow test, supplemented by the judgment of experienced concrete operators. Concrete specimens will then be made up in the proportions as determined by the trial method referred to, and the comparative strength (which should be constant), the comparative yield, and the comparative absorption will be determined.

In the third series of tests, specimens will be made in which the concrete mixture has been designed in accordance with the fineness modulus theory as given in "The Design and Control of Concrete Mixtures," a publication recently issued by the Portland Cement Association. The results obtained from this series will be used as a check against the results obtained in the second series.

Assuming a constant strength and a constant degree of workability, it is hoped to determine by means of these tests what grading of coarse aggregate and what proportions of fine to coarse will give the greatest yield of concrete for both crushed stone and gravel.

Tests of Vibrolithic Concrete

The Bureau of Public Roads, co-operating with the American Vibrolithic Corporation, recently conducted a 28-day test on concrete slabs, some constructed in accordance with ordinary methods, and others using the same materials but with the vibrolithic process. "The tests were made for the purpose of obtaining data on the relative strength of speciments equivalent in every particular except the method of construction. To that end, every effort was made to eliminate all variables except the methods of placing, tamping and finishing, and to have all operations performed under as nearly similar working conditions as possible."

The test will be continued for a year and at the end of that time additional examinations made "and the formulation of definite conclusions must await the completion of the latter tests. There are certain indications, however, which may be noted at this time with the understanding that they may be modified by the data obtained from the remaining tests."

"Giving due consideration to all features of the investigation, such as the workability of the concrete and the method of finishing the normal specimens, the following tentative conclusions may be drawn from the bending test at the age of 28 days:

"1. The vibrolithic process resulted in a more uniform product. 2. For a given cement content, slabs constructed by the vibrolithic method exhibited greater strength than the normal concrete. 3. The strength of the slabs constructed by the vibrolithic process, when tested with tension in the bottom, was practically the same as when tested with tension in the top. 4. The strength of the normal concrete, when tested with tension in the bottom, was less than when tested with tension in the top."

The test specimens were made in slabs 36x72 inches and designed to be 6 inches in depth. (The actual depths varied from 5.9 to 6.7 inches in the case of ordinary concrete and 5.9 to 6.6 inches in the case of vibrolithic.) They were constructed on a specially prepared subgrade which had been sprinkled and rammed thoroughly the day before placing the concrete and sprinkled again the morning the slabs were poured. The aggregates used were Potomac river sand and crushed limestone. When the slabs were to be tested, 28 days later, they were lifted from the subgrade and the adhering soil removed. Those that were to be tested with the bottom resting on the knife edges were prepared for the test by placing flat strips of steel 1¼ inches wide and 3/16 inches thick, set in plaster paris, to furnish a bearing for the knife edges.

One feature that was noticed on inspecting the broken slabs was that the action of the vibrator on the surface of the concrete was, apparently, to work down the mortar to the subgrade, while with the ordinary methods of finishing, voids occur at the bottom, thus reducing the strength of the slab as a beam.

Concerning the comparison of the two kinds of concrete, the report states: "It is believed that, if the concrete in the normal specimens had been more thoroughly compacted as would be the case in machine finishing, less variation in strength would have resulted and generally higher values would have been obtained." As a matter of fact, the same consistency was used for both normal and vibrolithic pavement and this was more nearly that which would be turned out in actual practice for machine finishing, rather than for hand finishing.

State Road Tests

The Maryland State Roads Commission is to conduct field tests to determine the relative merits of the conventional method of curing concrete with earth covering as compared to the use of sodium silicate or calcium chloride. The U. S. Bureau of Public Roads plans to have an observer present during the tests. Three sections of road, each about 4,000 ft. long, are to be laid for this purpose, about twenty miles from Washington. A unique feature

will be that double cylindrical molds are to be placed on the subgrade and filled and cured as part of the pavement, the concrete in these molds being tested at ages of 1, 3, 7, 14 and 21 days.

The Virginia Highway Commission is planning to construct a one-mile section of vibrolithic concrete on a Federal Aid road as a test section, which the Bureau of Public Roads plans to follow closely. Careful observation will be made of materials and methods of construction, and after completion, inspections will be made extending over a period of years.

Shovel Sizes and Varieties

A meeting of producers, distributors and users of shovels, spades and scoops met at Washington the first week in May, under the auspices of the Division of Simplified Practice of the Department of Commerce, and adopted a list of simplified sizes and varieties of shovels, to be effective July 1, subject to revision after one year from the date of application.

San Francisco Studying Refuse Disposal

The Health Committee of the Board of Supervisors of San Francisco has been considering a proposition to dispose of all of the city's refuse by sanitary fill on state tide lands. This has been due chiefly to complaints made against odors, smoke and burning papers from the antiquated city-owned incinerator. Members of the health committee have visited Portland, Seattle and Los Angeles to inspect the methods used in those cities. The city engineer of Berkeley has explained the sanitary fill method used there and a report on sanitary fills has been made to the committee by Professor Charles Gilman Hyde.

Scavengers now deliver about 600 tons of refuse daily to the incinerator, while garbage from downtown restaurants is sold directly to hog branches and several tons of paper and junk is salvaged and sold to dealers. The scavengers operate the incinerator through a co-operative organization, the city receiving no pay therefor. This organization collects from the scavengers one dollar per ton of refuse delivered at the plant.

A sanitary fill proposal is before the health committee which provides that the contractor will erect scales and a dumping platform at the fill to receive refuse, that machines will be installed to wash out the wagons and saturate the refuse with salt water under pressure, that the refuse will be covered with at least twelve inches of dirt and rock; in return for which the contractor shall receive sixty cents a ton for all refuse delivered and be given an exclusive contract for twenty-five years.

The committee is informed that such sanitary fills have been successful in Portland, Seattle and Berkeley, the two former filling large gulches and reclaiming valuable land, Portland having utilized some former dumps for public playgrounds. Berkeley has filled in tide lands for industrial sites. An incidental advantage is that the householder is not required to segregate the various kinds of refuse.

There are apparently sufficient tide lands in the southeastern part of San Francisco to provide sites for sanitary fills for years to come. On the assumption that refuse accumulates in proportion to density of population, there would be a greater ton-mile haul to the proposed fill than to the present incinerator, which is situated near the center of the city. This additional cost would be at least partially offset by the difference of forty cents a ton between the dollar now charged by the incinerator and the proposed charge of sixty cents at the fill. The cost would probably be further reduced by the use of trucks and trailers, by using gondola cars at convenient locations along the railroad, or by other up-to-date methods.

The committee is not now giving much thought to the matter of collection but it is thought probable that municipal collection and disposal may prove to be the best solution of the entire problem. In view of this probability it is held by some that any contract entered into with private parties for refuse disposal should provide that the city may acquire the rights and physical property involved upon terms and conditions agreed to in the contract.

Liquid Chlorine Patent Suit

A decision was rendered by the U. S. Circuit Court of Appeals on May 17th affirming a previous decree of the District Court which held that the Paradon Engineering Company is infringing the Ornstein patent for applying liquid chlorine to water, under which patent Wallace & Tiernan Co. operate in selling their apparatus. The decree of the lower court, which was affirmed by the Court of Appeals, enjoins the Paradon company "from directly or indirectly using or contributing to the use of the inventions covered by claims" which are sufficiently indicated by the fourth, which claims:

> In the sterilization of flowing water, the process which comprises establishing a separate minor flow of water, causing such minor flow to spread out in one portion of its path to present an extended surface, contacting chlorin gas with such flow in such portion of its path, thereafter uniting such minor flow of water with the main body of flowing water to be sterilized, and controlling the quantity of chlorin supplied to the main body of flowing water by controlling the rate of supply of chlorin gas to the minor flow of water.

And the Paradon company is enjoined "from making or causing to be made, using or causing to be used, selling or causing to be sold, or installing or causing to be installed any apparatus for use in the United States of America and its territories *in practicing the process of the said claims.*"

The suit was brought by the Electro Bleaching Gas Co., owner of the patent, and Wallace & Tiernan Co., the sole licensee.

Roads and Motor Vehicle Power

Dr. H. B. Shaw, director of the Engineering Experiment Station of North Carolina State College, is conducting experiments to learn the amount of power used in driving a vehicle over various types of road. The power used in covering a given distance is measured by registering the number of ampere-hours of electricity consumed by the motors of a specially devised electrically driven truck, using current from a large generator driven by an eight cylinder gasoline engine. A complete report of the experiments will be given to the 1927 convention of the American Road Builders Association.

Recent Legal Decisions

CONSTRUCTION OF GUARANTY BY CONTRACTOR OF MUNICIPAL WATER RESERVOIR

The Missouri Court of Appeals holds, City of Monett v. Gilloiz, 266 S. W. 759, that where a contract for the construction of a city water reservoir provided that it should be so constructed as to endure without repairs for three years, the contractor was bound thereby, even though the plans, specifications and all details of the work were prepared by the city. The obligation, however, did not oblige the contractor to build a reservoir that would withstand all ravages that might result from the negligence of the city and its agents. When the reservoir was completed it was filled with water and tested, to the satisfaction of the city engineer, and no leaks were found. If it were true, as the evidence tended to show, that the reservoir was left empty by the city, and that doing so and permitting the sun's heat to reach the floor of the reservoir would and did cause the leak of which complaint was made by the city, it was held that that result was not contemplated by the parties and was not covered by the contractor's guaranty. Whether this was done by the city and the leaks were caused thereby was held for the jury.

Substitution of creek gravel for crushed stone by the city would be no defense to the action by the city, since, if the contractor was not willing to allow his guaranty to cover the use of creek gravel, he should not only have protested, but should have refused to use it unless he was relieved from his guaranty.

CLAIMS AGAINST MUNICIPALITIES

The Oklahoma Supreme Court holds, McEwen Mfg. Co. v. Town of Covington, 239 Pac. 219 that under the Oklahoma statute claims against municipalities must be presented to the appropriate boards controlling the municipalities and disallowed before action in court can be brought thereon. The claimant, on either an express or implied contract, must be able to point out the law authorizing the indebtedness and the authority of the proper officers for incurring the same. It is not sufficient that the services performed or the things furnished were needful and beneficial.

FRANCHISE CONTRACT PROVISION FOR FREE WATER TO MUNICIPALITY

The Washington Supreme Court holds, Monroe Water Co. v. Town of Monroe, 237 Pac. 996, that Rem. Comp. St. §10390, as to regulation of a water company's rates, gives the Department of Public Works no power to abrogate a provision in a water company's franchise from a municipality requiring the company to furnish water for municipal purposes free of charge. The contracts referred to in the section are with "persons" and "corporations," which terms, under section 10344, are held not to include municipal corporations.

ORDINANCE REQUIRING DISCRIMINATORY FEE FOR WATER CONNECTIONS HELD VOID

The Texas Court of Civil Appeals holds, Town of Highland Park v. Guthrie, 269 S. W. 193, that V. S. C. St. 1914, art. 772 b., requiring rates charged by lighting and water systems to be equal and uniform, is simply declaratory of the common law. It applies to municipal corporations supplying these commodities as well as to public service corporations, and an ordinance requiring a fee per front foot for water or sewerage connections which does not apply to all parts of the municipality is void.

POLLUTION OF STREAMS BY SEWAGE

The Oklahoma Supreme Court holds, City of Tecumseh v. Deister, 239 Pac. 582, that while the construction by a municipal corporation of a sewer system and the erection of a septic tank for treating or purifying the sewage is not a nuisance per se, it may, after construction, be operated in such manner as to create a nuisance, and the maintenance of such nuisance renders the municipal corporation liable in damages to an adjacent landowner who is injured thereby, whether such landowner acquired title to the land prior or subsequent to the construction of the sewer and septic tank where the action is founded, not upon the faulty or negligent construction thereof, but upon the nuisance created by the negligent and faulty operation which caused the injury.

When a municipal corporation discharges sewage in a creek, polluting the waters of the stream, or discharges it into a dry channel, where the rainfall will cause the sewage to be washed through and upon, and deposited upon the lands of another, to the injury of such owner, and the sewage so deposited and discharged causes the air to be impregnated with foul and noxious odors, offensive to the smell and injuriously affecting the comfort and repose of the adjacent landowner in his enjoyment of the premises, and the sewage so deposited works injury to the live stock and crops of the owner of the land, the Oklahoma court holds that the municipal corporation is liable for damage arising from the maintenance of the nuisance so created.

MUNICIPALITY HELD NOT LIABLE FOR NON-PERFORMANCE BY OFFICERS OF DUTY TO KEEP PARKS SAFE FOR PUBLIC

The Georgia Appeal Court holds, Miller v. Mayor, etc., of Savannah, 126 S. E. 867, that where a city maintains a park primarily for the use of the public, intended as a place of resort for pleasure and promotion of health of the public at large, its operation is in virtue of the governmental powers of the municipality, and no municipal liability would attach to the non-performance or improper performance of the duties of the officers, agents or servants of the city in respect to keeping the park safe for use by members of the general public.

POWER TO ISSUE MUNICIPAL BONDS

The North Carolina Supreme Court holds, Winstead v. Williams, 128 S. E. 46, that a city or town may issue bonds, exclusive of water, sewer and light bonds, to the full amount of 8 per cent. of the assessed value of property therein, regardless of the bonded debt of other political subdivisions covering in whole or in part the said city or town.

INADEQUACY OF FIRE FIGHTING FACILITIES HELD NO JUSTIFICATION FOR ORDINANCE RESTRICTING BUILDING

The New Jersey Supreme Court, Ingersoll v. Village of South Orange, 128 Atl. 393, is of opinion that, the duty resting on the municipal authorities of a village to provide reasonably proper and adequate fire protection, the adequacy of the fire department should not be maintained by a provision in a zoning ordinance prohibiting the erection of apartment houses.

PUBLIC WORKS CONTRACT PROVISION AWARDING SUM FOR COMPLETION BEFORE DATE FIXED AND REQUIRING PENALTY FOR DELAY HELD VALID

The Kentucky Court of Appeals holds, Henry Bickel Co. v. Comrs. of Sewerage of Louisville, 268 S. W. 1096, that a statutory requirement that work shall be by contract awarded to the lowest and best bidder is fully met when the form of contract is shown in the public proposal for bids, and all the bidders bid with knowledge of the form of contract to be executed. A provision in such a contract giving the contractor $25 for each day he finished the work before the time fixed in the contract, and requiring him to pay the same amount for each day he delayed completion, was held valid.

REMEDY TO OBTAIN CERTIFICATE THAT MONEY FOR PUBLIC IMPROVEMENT IS AVAILABLE—CUSTODY OF HIGHWAY PLANS AND SPECIFICATIONS

The Ohio Supreme Court holds, State v. Baker, 147 N. E. 501, that, under the statute, in counties where a resident engineer has been appointed by the state highway commissioner to superintend the construction of state highways, the plans and specifications should be kept on file in the resident engineer's office.

It is also held that under section 2288-2 Ohio General Code, no public improvement constructed by the expenditure of state funds can lawfully proceed unless the director of finance shall first certify that there is a balance in the appropriation not otherwise appropriated to pay precedent obligations. If the money is in fact in the fund, it is the director's ministerial duty to make the required certificate, and this may be compelled by mandamus.

CARE OF MUNICIPALITY IN MAINTAINING ELECTRIC LIGHT WIRES IN STREETS

The Mississippi Supreme Court holds, Williams v. City of Canton, 103 So. 811, that a corporation, private or municipal, engaged in the business of transmitting electricity along highways or streets, is charged with the highest degree of care for the safety of persons lawfully using such highways.

In an action against a municipality owning and operating an electric light plant for the death of a child caused by coming in contact with a highly charged wire which had fallen in a street, it is held that the fact, unexplained, that the wire had fallen in the street was prima facie evidence of negligence on the part of the municipality, and it thereupon devolved upon the municipality to meet or rebut this prima facie case by evidence that it exercised the highest degree of care in maintaining its wires in such condition as not to endanger the public.

(The phrase "highest degree of care" does not necessarily mean that a greater burden is imposed on the utility than by those courts which declare the duty to be the exercise of "ordinary care under the circumstances.")

ORDINANCE REQUIRING PERMIT FOR CONVERSION OF FRAME BUILDING HELD VALID

The New Jersey Supreme Court holds, Manning v. Hague, 128 Atl. 375, that a city ordinance requiring an application to the building department for a permit to convert a frame dwelling house to business premises and living apartments is a valid and reasonable exercise of the city's police power to protect against fire.

DISPOSAL OF TAX COLLECTOR'S COMMISSION ON ROAD DISTRICT MAINTENANCE FUNDS

The Mississippi Supreme Court holds, Board of Supervisors of Lowndes County v. Robertson, 103 So. 435, that under Miss. Laws 1920, c. 122, §§19, 27, in view of the express exceptions therein, the tax collector's commissions on road district maintenance funds are not among the commissions directed to be paid into the general county treasury, but are properly paid as part of the whole sum collected to the credit of the road district maintenance fund.

CONTRACT FOR HAULING AND LOADING ROCK

The Arkansas Supreme Court holds, Martin v. Martin, 272 S. W. 660, that, in an action for damages for breach of a contract for hauling and loading rock letters relating to a contract by which the defendant was to furnish rock to another were inadmissible, that contract being independent of, and having no relation to, the contract in suit.

The evidence was held to support a finding by the jury that the plaintiff contracted with the defendant to haul and load 300 cars of rock at $1.50 per yard, and that he was wrongfully prevented from loading 83 cars, received only $1.35 for 58 cars and was not paid $.15 per yard profit on 71 cars loaded by his subcontractor, as agreed.

HIGHWAY CONTRACTOR'S LIABILITY ON CONTRACT AND BOND

The Indiana Appellate Court holds, Paso v. State ex. rel. Board of Comrs. of Clark County, 147 N. E. 287, held that the board of commissioners, having refused to relieve a highway contractor from his contract under the Indiana Contractor's Relief Act, 1919, the board was without authority to reverse its order, and, irrespective of the constitutionality of the Act, the contractor remained liable on his contract and bond.